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Economic Impact of Implementing RACT (Reasonably Available Control Technology) Guidelines for Paper Coating in the State of Massachusetts

Booz-Allen and Hamilton, Inc, Florham Park, NJ

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16. ABSTRACT

The major objective of the study was to determine the direct economic impact of implementing RACT guidelines for paper and fabric coating in the state of Massachusetts. It is to be used primarily to assist EPA and the state in the development of implementation plans to achieve air quality goals.

Total capital costs, annualized cost and energy consumption for control methods to achieve RACT emissions guidelines statewide for paper and fabric coating were estimated; in addition the direct impact of these upon the state's economy was addressed. Discussed also were selected secondary impacts such as employment, market structure and productivity, though these were given only a minor emphasis.

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ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES FOR PAPER COATING AND FABRIC COATING IN THE STATE OF MASSACHUSETTS

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TO STATES AND EPA CARRYING OUT REQUIREMENTS
OF CLEAN AIR ACT AND APPLICABLE FEDERAL
AND STATE REGULATIONS

Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY
AIR PROGRAMS BRANCH
Boston, Massachusetts

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From:

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May, 1979

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1.0 INTRODUCTION AND OVERALL STUDY APPROACH

1.0 INTRODUCTION AND OVERALL STUDY APPROACH

This report summarizes the estimated economic impact of the implementation of RACT guidelines[1] in the State of Massachusetts for two categories:

- Paper coating
- Fabric coating.

The results of the individual studies are summarized in Chapters 2 and 3 of this report. Each contains a detailed discussion of the methods of approach, the quality of estimates, the estimated costs of compliance and secondary economic impacts.

This introductory section discusses the background of the overall study and other issues and factors which are common to both studies.

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[1] Based on suggested guidelines as outlined in Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001, April 1978.

1.1 BACKGROUND

The Clean Air Act Amendments of 1977 required the states to revise their State Implementation Plans (SIPs) to provide for the attainment and maintenance of national ambient air quality standards in areas designated as nonattainment. The Amendments require that each state submit the SIP revisions to the U.S. Environmental Protection Agency (EPA) by January 1, 1979. These proposed regulations should contain an application of Reasonably Available Control Technology (RACT) to stationary sources for which the EPA has published guidelines. The Amendments also require that the states identify and analyze the air quality, health, welfare, economic, energy and social effects of the plan provisions.

Under the direction of Region I, the EPA contracted with Booz, Allen & Hamilton Inc. (Booz, Allen) to assist the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut in analyzing the economic, energy and secondary impacts of the SIP revisions proposed by these states. The assignment was initiated in August 1978, and authorization to proceed on the study areas specific to Rhode Island was received on November 9, 1978.

After a review with each of the states and EPA Region I representatives, a work scope was defined that would include in the study an analysis of the direct economic and energy impacts for those industrial segments most likely to have a significant impact at the statewide level. For the most part, this included industrial categories that had more than a few facilities potentially affected.

1.2 SUMMARY OF PROPOSED SIP REVISIONS IN MASSACHUSETTS

Massachusetts has proposed statewide regulations to reduce volatile organic compound (VOC) emissions by implementing the Reasonably Available Control Technology (RACT) guidelines developed by the EPA for existing stationary sources.

State officials provided guidance in determining their need for support in analyzing the economic impact of the SIP revisions. The analysis of implementing the RACT guidelines for reducing VOC emissions was expressed as the fundamental concern. Specifically, the state needed assistance in the analysis of two of the 15 industrial categories for which the EPA has published RACT guidelines, surface coating of paper and fabrics. Exhibit 1-1, on the following page, presents briefly the limitations imposed by the RACT guidelines in these two areas. These two RACT industrial categories are described in the next sections. The State of Massachusetts[1] plans to exempt plants with annual coatings emission potentials of less than 100 tons per year (TPY) from a single site in each RACT category. This exemption may be reduced to 25 TPY in urban areas in the future. The cost estimate for paper and fabric coating included in this study covers the 100 TPY limitation. In addition, costs related to a possible 25 TPY limit are estimated roughly.

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[1] Annual emission potential is defined herein as the maximum emissions of a pollutant in the absence of air pollution control equipment when operating at maximum capacity for 24 hours per day, 365 days per year. For purposes of this study, it was assumed that emission inventory information supplied by the State of Massachusetts was based on plants operating at maximum capacity over a specifically reported number of hours per year.

EXHIBIT 1-1
U.S. Environmental Protection Agency LISTING OF EMISSION LIMITATIONS THAT REPRESENT THE PRESUMPTIVE NORM TO BE ACHIEVED THROUGH APPLICATION OF RACT FOR SPECIFIC INDUSTRY CATEGORIES

Category	RACT Guideline Recommendations
Surface coating of paper	An emissions limitation of 2.9 pounds of solvent per gallon of coating minus water.
Surface coating of fabrics	For coating on a fabric substrate an emission limitation of 2.9 pounds of solvent per gallon of coating minus water.
	For coating on a vinyl substrate an emission limitation of 3.8 pounds of solvent per gallon of coating minus water.

Source: Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001, April 1978.

1.3 SCOPE OF THE STUDY

The primary objective of this study is to determine the costs and impact of compliance with the proposed SIP revisions. The study emphasizes the analysis of direct economic costs and energy effects of the proposed SIP revisions. Benefits and selected secondary economic impacts, such as employment, are also addressed.

General study bases used in the determination of the impact of RACT compliance included:

- The use of emission limitations for each industrial category at the control level or by methods specified by the RACT guidelines[1]. These are presented in Exhibit 1-1.
- Adjustment of costs and emission data to a 1977 basis.
- The inclusion of stationary point sources where total plant site annual emission potential is 100 TPY or greater.
- The exclusion of sources using the following volatile organic compounds:
  - Methane
  - Ethane
  - Trichlorotrifluorethane (Freon 113)
  - 1,1,1-trichloroethane (methyl chloroform)[2].
- The assumption that compliance is required by April 1, 1981, for surface coating of paper and fabrics.
- The use of generalized average cost factors rather than individual engineering estimates. It is recognized that average costs cannot be accurately applied to individual situations and significant errors might result in individual plant estimates. Thus, while costs were estimated on a plant-by-plant basis, the total cost derived is probably more accurate than its individual elements. Industries with a small number of plants, such as in paper coating, have greater potential for error than those with a large number.

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[1] EPA-905/2-78-001, op. cit.

[2] The exemption status of methyl chloroform under these guidelines may be subject to change.

Other assumptions and specific guidelines are discussed more fully in the two chapters concerning paper coating and fabric coating.

Furthermore, the study is limited to estimates of costs and other economic effects at the industry level. Evaluation of the overall effect of the regulatory proposal on the State of Massachusetts (macroeconomic effects) was not included within the study scope, because the segments studied represent only a small portion of the overall regulations proposed.

1.4 STUDY APPROACH

The methods used for the evaluation of the economic impacts of compliance for the two RACT categories summarized in this report were essentially the same. Initially they both involved a review of state emission inventories and various directories to establish the locations of plants which might be affected by the proposed regulations. This was followed by a telephone survey to confirm the processes used by each plant, emission rates, compliance plans and other pertinent factors. The results of the survey were then used as a basis for final cost estimation on a plant by plant basis using generalized cost estimation factors.

The specific study methodologies for paper coating and fabric coating are discussed in detail in the appropriate chapters.

1.4.1 Process Descriptions

For each of the industrial categories, the basic technology and emission data were reviewed and summarized concisely for subsequent evaluation of engineering alternatives. In this task, the RACT guideline studies, prepared for each industrial category, and other air pollution control engineering studies served as the basis for defining technological practice. Additional alternatives of control that met the requirements of the RACT guidelines were identified from a literature search. The most likely control alternatives were assessed and evaluated by:

- Technical staff at Booz, Allen
- Interviews with industry representatives
- Interviews with EPA representatives
- Interviews with equipment manufacturers.

1.4.2 Cost of Controlling VOC Emissions

The cost of control to meet the requirements of the RACT guidelines was obtained from related RACT studies, other technical EPA studies, trade journal technical articles and interviews with industry representatives. In general, the approach applied in developing capital and annualized cost estimates was to:

- Determine the control alternatives industry is likely to apply

- Utilize available secondary source information as the initial cost data source and then to confirm with industry representatives

- Estimate costs based on secondary source information adjusted as a result of discussions with industry representatives.

These estimated costs are not, therefore, to be considered as detailed engineering costs. Such detail was beyond the intent or scope of this project.

Cost data presented within the body of the report were standardized in the following manner:

- All cost figures are presented for a base year, 1977.

- Capital cost figures represent installed equipment cost including:

    - Engineering
    - Design
    - Materials
    - Equipment
    - Construction.

- The capital cost estimates do not account for costs such as:

    - Cleanup of equipment
    - Lost sales during equipment downtime
    - Equipment startup and testing
    - Initial provisions (spare parts).

- Annual operating costs of compliance with the RACT guidelines were estimated for each of the control alternatives studied. The annual operating costs included were:

    - Direct labor
    - Raw material costs (or savings)
    - Energy
    - Product or fuel recovery cost (or savings).

- Other types of costs, not included in this analysis, involve compliance costs, such as:

    - Demonstration of control equipment efficiency

    - Supervisory or management time

    - Cost of labor or downtime during installation and startup.

- The annualized cost is the total of direct operating costs (including product or raw material recovery) and the capital related annual costs. Derivation of the capital related annual costs is described next.

1.4.3 Derivation of Capital Related Annualized Costs

Three factors are included in this estimating procedure for capital related annual costs:

- Depreciation and interest charges
- Taxes, insurance and administrative overhead
- Maintenance costs.

These factors are described below, along with the figure to be used in most situations. Other values might be used in specific situations based on individual data available for specific industries. These generalized figures assume that the greater part of the capital investment will involve installation of retrofitted collection systems and incinerators or carbon adsorption controls.

Depreciation and interest charges are based on a formula supplied by EPA for an equal payment series capital recovery factor:

$$A = P\left(\frac{i(1 + i)^n}{(1 + i)^n - 1}\right)$$

where:

A = annualized charge for depreciation and interest

P = initial amount invested

i = annual interest rate

n = life of investment in years

For the current study, the interest rate (i) is assumed to be 10 percent, based on guidance provided by EPA.[1] Investment life (n) is assumed to be 10 years. This is based on figures used in other studies, generally ranging from 10 to 12 years. The lower figure was selected as most applicable because, with retrofit situations, the useful life of the equipment is affected both by its own life and by the remaining life of the system to which it is added. When major modifications would be required to a processing line (such as automobile assembly plants) that would affect the useful life of the facility, a lower investment life should be applied.

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[1] Information provided by Allen Basala Economics Analysis Branch, OAQPS, EPA.

Application of this formula provides a depreciation and interest figure of 0.16275, which is rounded to 16 percent.

Taxes, insurance and overhead are estimated to average 4 percent per year, based on guidance provided by EPA.[1,2]

Maintenance is estimated to average 5 percent per year, based on OAQPS guidelines for incinerators,[2] past experience of the study team and a review of economic impact analyses prepared in the past.

The total annualized cost of capital investment is, therefore, estimated to be 25 percent of the capital cost. This figure was derived by totaling the three figures presented above. Twenty-five percent is the same figure as that presented in the OAQPS Guidelines for use in incineration and carbon adsorption for surface coating operations.[2]

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[1] Information provided by Allen Basala, Economics Analysis Branch, OAQPS, EPA.

[2] Control of Volatile Organic Emissions from Existing Stationary Sources--Volume I: Control Methods for Surface Coating Operations, EPA-450/2-76-028, November 1976 (p. 103 & 129)

1.5 COMPARISON OF DIRECT COST WITH SELECTED DIRECT ECONOMIC INDICATORS

In each of the industrial categories studied, the costs (or savings) of compliance were determined and then compared with selected economic indicators. This comparison was performed to gain a perspective on the compliance costs rather than to estimate price changes or other secondary effects of the regulation. Presented below are typical comparisons of direct costs with indicators that are presented in this study.

- Annualized cost in relation to current price--To gain a perspective on the compliance cost in relation to current prices of the manufactured items at the potentially affected facilities, the annualized cost is presented in terms of a price increase assuming a direct pass-through of costs to the marketplace.
  - This analysis was based on the average cost change (including those facilities that may have little or no economic impact associated with meeting the proposed standards) divided by the average unit price of goods manufactured.
  - For this reason as well as many others (that might be addressed in a rigorous input-output study to estimate eventual price increase), this analysis should not be interpreted as a forecast of price changes resulting from the proposed standards.
- Annualized costs as a percent of current value of shipments--The annualized costs applied are for all those facilties potentially affected divided by the estimated value of shipments for the statewide industrial category (i.e., including those facilities which currently may meet the proposed standard). This approach tends to understate the effect on those specific firms requiring additional expenses to meet the proposed standard. Therefore, when available, the compliance cost is also presented as a percent of the value of shipments for only those firms not currently meeting the proposed regulation.

- Capital investment as a percent of current annual capital appropriations--Estimated statewide capital investment for the potentially affected facilities divided by the estimated capital appropriations for the industry affected as a whole in the state (including those facilities that may not reqire any capital investment to meet the proposed standard). This approach tends to understate the effect on those specific firms requiring additional expenses to meet the proposed standard. Therefore, when available, the compliance cost is also presented as a percent of the capital appropriations for only those firms not currently meeting the proposed regulation.

1.6 DEFINITIONS OF TERMS

Listed below are definitions of terms that may be used in the body of the report:

- Annualized cost--the sum of annual operating costs (fuel, labor, materials, etc.) and an annual capital charge for depreciation, taxes, insurance, interest and administrative overhead (25% of initial capital is used in this study) involved in meeting compliance requirements.
- Capture system--the equipment (including hoods, ducts, fans, etc.) used to contain, capture or transport a pollutant to a control device.
- Cost increase per unit of production--annualized cost divided by the number of the appropriate units of production, such as pounds or square feet.
- Coating applicator--an apparatus used to apply a surface coating.
- Coating line--one or more machines or operations which include a coating applicator, flash-off area and oven, wherein a surface coating is applied, dried and/or cured.
- Control device--equipment (incinerator, adsorber or the like) used to destroy or remove air pollutant(s) prior to discharge to the ambient air.
- Direct cost pass-through--the direct annualized compliance cost (increase or decrease) to meet the RACT limitations in terms of units produced (costs per unit value of manufactured goods).
- Emission--the release or discharge, whether directly or indirectly, of any air pollutant into the ambient air from any source.
- Facility--any building, structure, installation, activity or combination thereof which contains a stationary source of air contaminants.
- Flash-off area--the space between the application area and the oven.
- Hydrocarbon--any organic compound of carbon and hydrogen only.

- Incinerator--a combustion apparatus designed for high temperature operation in which solid, semisolid, liquid or gaseous combustible wastes are ignited and burned efficiently and from which the solid and gaseous residues contain little or no combustible material.
- Organic material--a chemical compound of carbon excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate.
- Oven--a chamber within which heat is used to bake, cure, polymerize and/or dry a surface coating.
- Plant or premises--a manufacturing location.
- Prime coat--the first film of coating applied in a two-coat operation.
- Reasonably available control technology (RACT)--the lowest emission limit as defined by EPA that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility. It may require technology that has been applied to similar, but not necessarily identical, source categories.
- Reid vapor pressure--the absolute vapor pressure of volatile crude oil and volatile nonviscous petroluem liquids, except liquified petroleum gases, as determined by American Society for Testing and Materials, Part 17, 1973, D-323-72 (Reapproved 1977).
- Shutdown--the cessation of operation of a facility or emission control equipment.
- Solvent--organic material which is liquid at standard conditions and which is used as a dissolver, viscosity reducer or cleaning agent.
- Standard conditions--a temperature of 20°C (68°F) and pressure of 760 millimeters of mercury (29.92 inches of mercury).
- Startup--the setting in operation of a source or emission control equipment.

- Stationary source--any article, machine, process equipment or other contrivance from which air pollutants emanate or are emitted, either directly or indirectly, from a fixed location.

- Topcoat--the final film of coating applied in a multiple coat operation.

- True vapor pressure--the equilibrium partial pressure exerted by a volatile organic liquid as determined in accordance with methods described in American Petroleum Institute Bulletin 2517, "Evaporation Loss from Floating Roof Tanks," 1962.

- Equivalent barrel of oil--energy demand is converted into barrels of oil at the conversion rate of 6,000,000 BTU per barrel of oil.

- Volatile organic compound (VOC)--any compound of carbon that has a vapor pressure greater than 0.1 millimeters of mercury at standard conditions excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates and ammonium carbonate.

1.7 QUALITY OF ESTIMATES

The quality of the estimates that are presented in this report can be judged by evaluating the basis for estimates of the individual study components. In each of the chapters that deal with the development of estimated compliance cost, the sources of information are fully documented. In addition, the study team has categorically ranked the overall data quality of the major sources and, therefore, of the outcomes. These data quality estimates were ranked into three categories:

- High quality ("hard data A")--study inputs with variation of not more than ± 25 percent
- Medium quality ("extrapolated data B")--study inputs with variation of ± 25 to ± 75 percent
- Low quality ("rough data C")--study inputs with variation of ± 50 to ± 150 percent.

Each of these data quality estimates is presented in the individual chapters. The overall quality ranking of the study inputs for each RACT industrial category was generally in the medium quality range.

2.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING PAPER IN THE STATE OF MASSACHUSETTS

2.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING PAPER IN THE STATE OF MASSACHUSETTS

This chapter presents a detailed analysis of the impact of implementing RACT for plants in Massachusetts which are engaged in the surface coating of paper. This is meant to include protective or decorative coatings put on paper, pressure-sensitive tapes regardless of substrate, related web coating processes on plastic film and decorative coatings on metal foil, but does not include conventional printing processes which apply inks.

This analysis includes those paper coaters in the nonattainment area with potential emissions over 100 tons per year.

The chapter is divided into five sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines; previous studies of paper coating; interviews with paper coaters, coating equipment and materials manufacturers; and a review of pertinent published literature.

2.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impacts

for plants engaged in the surface coating of paper. The quality of these estimates is discussed in the last part of this section.

2.1.1 Industry Statistics

Paper coating is practiced in a number of industries. Among products that are coated using organic solvents are: adhesive tapes; adhesive labels; decorated, coated and glazed paper; book covers; office copier paper; carbon paper; typewriter ribbons; photographic film; paper cartons; and paper drums. The firms coating paper are classified in a number of groupings in the U.S. Department of Commerce's Standard Industrial Classification system. The major coaters may be found in the following 16 SIC groups:

SIC	Description
2611	Pulp mills
2621	Paper mills, except building paper mills
2631	Paperboard mills
2641	Paper coating and glazing
2643	Bags, except textile bags
2645	Diecut paper and paperboard and cardboard
2649	Paper converting, n.e.c.
2651	Folding paperboard boxes
3291	Abrasive products
3292	Asbestos products
3293	Gaskets, packing and sealing devices
3497	Metal foil and leaf
3679	Electronic components, n.e.c.
3842	Orthopedic, prosthetic and surgical appliances and supplies
3861	Photographic equipment and supplies
3955	Carbon paper and inked ribbons

This list does not include plants listed in the SIC category 2700 (Printing, Publishing and Allied Industries), where paper coating other than printing may also be a part of the overall processing of the printed product.

Statistics concerning these industries were obtained from a number of sources. All data where possible were converted to the base year 1977 for the state, using scaling factors developed from U.S. Department of Commerce data as presented in County Business Patterns. The primary sources of economic data were the 1972 Census of Manufactures and 1976 Annual Survey of Manufactures. The 1978 Directory of Massachusetts Manufacturers and industry oriented annuals such as Lockwoods' Directory, Davidson's Blue Book and the Thomas Register of American Manufacturers were used to identify some of the individual companies engaged in paper conversion (i.e., coating of paper in roll form for sale to other manufacturers) and to identify other paper coating firms in the state.

The actual firms expected to be affected by the proposed regulations were identified from this tentative list by crosschecking the firms with a list prepared by the Massachusetts Department of Environmental Quality Engineering.

Of the list of 19 firms provided by the state, four of those contacted were not actually coaters but printers, or were manufacturers of plastic parts or used processes not classified as coating.

2.1.2 VOC Emissions

Emissions data compiled by the Massachusetts Department of Environmental Quality Engineering were used as the basis for estimation of the total VOC emissions from paper coating firms identified. This data base included information on types and efficiency of current controls, which was refined during industry interviews. The estimated total emissions now are believed to represent 90 percent or more of the emissions in this RACT category. Emissions from other paper coating plants, which may not have been identified, are expected to be small in terms of VOC emissions accounted for in this analysis.

2.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from sources included in the paper coating category are described in Control of Volatile Organic Emissions From Existing Stationary Sources, Volume II (EPA-450/2-77-008). The feasibility of applying the various control methods to paper coating discussed in this document was reviewed with coating firms, coating suppliers, coating equipment manufacturers and industry associations. These methods include both coating reformulation and the use of control devices, such as incinerators and carbon adsorbers.

Because of the wide variety of coating processes and coating materials in use, most methods of control will find some applicability. The situations where emissions are likely to be controlled by reformulation and by control devices were estimated based on a review of the literature and on information obtained from interviews.

2.1.4 Cost of Control and Estimated Reduction of VOC Emissions

The overall costs of control of VOC emissions in accord with the proposed regulations were determined from:

- The current level of emissions at those facilities potentially affected and selection of the type of control to be used, based on telephone interviews with personnel at plants in Massachusetts expected to be affected by RACT
- A development of capital, annualized cost and energy requirements for the facilities that will be affected, using generalized cost correlations corrected for escalation and other factors
- Aggregation of the findings for plants affected.

In the telephone survey all 19 firms on the original Massachusetts list and additional firms identified from directories were interviewed. This resulted in the identification of 17 plants in the state expected to be affected by the proposed paper coating regulations. Typically these interviews were directed to determining:

- If a coating process expected to be affected by the proposed regulations were used in the plant

- If the emissions in the state inventory were up to date

- What were the operating hours, solvent system, compositions, feasibility of combining emissions, allowable solvent concentrations in oven exhausts, etc., to enable selection of a probable method of control and estimation of costs

- What evaluation of alternative control methods (if any) had been made

- What would be the expected effect of the regulations on the firm such as employment, increase in prices, etc.

The generalized cost information used is presented in Control of Volatile Organic Emissions from Existing Stationary Sources, Volume I (EPA-450/2-76-028.

Additional cost data were supplied by equipment and material suppliers and published literature sources. Major coaters in Massachusetts, as well as in other states, were consulted to determine industry views on acceptable control methods and, in some cases, to confirm the cost estimating formulas.

Details of the method of calculation of costs are presented in Section 2.4.2 and Appendix A of this report.

2.1.5 Economic Impacts

The projected effect of RACT implementation on cost is based on an indicator which is the incremental cost related to the total sales or cost of the product within the state. The procedure is described below:

- Relate incremental costs to total statewide value of shipments

- Also relate incremental costs to the part of the statewide production that is affected by the regulation (firms not now meeting RACT)

- Where data are available, show the range of ratios for individual plants affected

- Where the industry has been segmented, show the range of cost ratios for applicable industry segments.

The cost per unit of production is an indicator of potential price effect rather than a prediction of the price effect to be expected.

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in the state.

2.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of paper in Massachusetts. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are published for the base year); "B" indicates data that are reasonably reliable and extrapolated to Massachusetts from hard data covering the U.S. such as value of shipments for four digit SIC groups where they were not available in state level tabulations; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 2-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 2-1
U.S. Environmental Protection Agency
DATA QUALITY--SURFACE COATINC OF PAPER

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions	X		
Cost of emissions control		X	
Economic impact			X
Overall quality of data		X	

Source: Booz, Allen & Hamilton Inc.

2.2 INDUSTRY STATISTICS

Industry characteristics, statistics and trends for paper coating in Massachusetts are presented in this section. This information forms the basis for assessing the total impact of implementing RACT for control of VOC emissions in the state and for the effect upon individual firms.

2.2.1 Size of the Industry

The 1978 Directory of Massachusetts Manufacturers and Lockwood's Directory report a total of 409 firms in 16 SIC categories in Massachusetts where paper coating, as defined in proposed RACT guidelines, is the main business of the firm or may be a part of its manufacturing activity. The number of firms and other relevant statistics in each SIC grouping are summarized in Exhibit 2-2, on the following page.

Total value of shipments for these firms is estimated to be about $3.26 billion, with a total of about 46,300 employees. New capital expenditures are estimated to be about $160 million annually, based on the most recent (1976) Annual Survey of Manufactures.

Of the total 409 firms, 17 have been identified as actual paper coaters as defined by the RACT guide lines. (These are listed in Exhibit 2-5 in Section 2.3.3). Of these, five are reported to meet the proposed standard--four because they use low solvent coating materials and one because its potential emissions are less than 100 tons per year in a rural area.[1] The remaining 12 firms are expected to be directly affected by the proposed standard. (See the discussion in Section 2.4). Ten of these firms have potential emissions over 100 tons per year and two have potential emissions between 25 and 100 tons per year. The total annual value of shipments of all 17 firms is estimated at $960 million, by calculating the value of shipments for each firm using the average value of shipments per employee for the appropriate SIC group from Exhibit 2-2. For the ten affected firms with emissions over 100 tons per year, the value of shipments is estimated to be $560 million; and for those with emissions between 25 and 100 tons per year, the value of shipments is estimated to be $150 million.

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[1] Potential emissions are those which would be released from a plant if it operated at rated capacity for 24 hours per day, seven days a week.

Exhibit 2-2

U.S. Environmental Protection Agency
1976 INDUSTRY STATISTICS—SURFACE
COATING OF PAPER SIC GROUPS IN MASSACHUSETTS

SIC Code	Description	Number of Plants	Total Number of Employees	Total Payroll ($ million)	Estimated Value of Shipments[a] ($ million)	Estimated New Expenditures[a] ($ million)
2611	Pulp mills	1	20	0.355	2.72	0.516
2621	Paper mills, except building paper mills	35	6,500	1.08	623	57.5
2631	Paperboard mills	7	750	12.6	43.8	10.5
2641	Paper coating and glazing	39	3,446	44.6	279	8.70
2643	Bags, except textile bags	20	1,126	13.2	78.0	2.25
2645	Diecut paper and paperboard and cardboard	11	375	4.44	26.2	0.757
2649	Paper converting, n.e.c.	22	3,338	46.8	196	4.01
2651	Folding paperboard boxes	30	2,343	27.9	134	4.07
3291	Abrasive products	23	5,806	78.5	350	11.3
3292	Asbestos products	5	375	4.74	23.2	0.490
3293	Gaskets, packing and sealing devices	12	471	6.37	18.1	0.661
3497	Metal foil and leaf	2	55	0.742	4.55	0.111
3679	Electronic components, n.e.c.	128	7,059	88.8	309	13.2
3842	Orthopedic, prosthetic and surgical appliances and supplies	33	1,750	19.7	77.1	2.72
3861	Photographic equipment and supplies	38	12,000	207	1,028	41.9
3955	Carbon paper and inked ribbons	3	900	11.2	70.7	1.32
Total		409	46,314	568	3,260	160

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a. Estimated by using ratios of (value of shipment/total employment) and (capital expenditures/total employment) for each SIC group as published in 1976 Annual Survey of Manufactures where value of shipments are not tabulated for the state.

b. None listed.

Source: Booz, Allen & Hamilton Inc.: 1976 County Business Patterns, and 1976 Annual Survey of Manufactures, U.S. Department of Commerce and the 1978 Directory of Massachusetts Manufacturers.

2.2.2 Comparison of the Industry to the State Economy

A comparison of the value of shipments of the 409 plants in the 16 SIC categories listed in Section 2.1.1 with the total state manufacturing economy ($27.9 billion) indicates that these plants represent about 12 percent of the total value of manufacturing shipments in Massachusetts. These 409 firms employ about 8 percent of the 580,000 manufacturing employees in the state. The 17 firms having paper operations affected by the proposed regulations represent about 2.6 percent of the total value of manufacturing shipments in Massachusetts and employ about 1.2 percent of all manufacturing employees.

The ten directly affected firms, with potential emissions greater than 100 tons per year, represent 1.5 to 1.9 percent of the total value of manufacturing shipments in Massachusetts and employ about 1.2 percent of all manufacturing employees.

Because several of the firms manufacture other goods in addition to coated paper, the figures cited about probably represent an upper limit.

2.2.3 Historical and Future Patterns of the Industry

Nationwide, the growth rate of the industries expected to be affected by the proposed paper coating regulations, in general, exceeds the growth rate of the economy. As summarized in Exhibit 2-3, the value of shipments increased in every category between 1972 and 1976, with an average annual growth rate of about 12.1 percent over the period. Compared to an average inflationary rate of 6 to 8 percent, this is equivalent to a real growth rate of 4 to 6 percent. In some individual categories, growth rates were even greater. Paper production increased by an average annual growth (actual dollars) rate of 16.5 percent; metal and foil by 16 percent; only slightly less than the average. It is expected that the growth rate will continue at these rates for the near future.

EXHIBIT 2-3
U.S. Environmental Protection Agency
HISTORICAL TRENDS IN VALUE OF SHIPMENTS OF
U.S. PLANTS ENGAGED IN PAPER COATING ($ millions)

SIC Code	1972	1973	1974	1975	1976
2611	710	849	1,525	1,630	2,055
2621	6,385	7,514	9,942	9,650	11,768
2631	4,153	4,862	6,516	6,055	6,724
2641	1,954	2,284	2,645	2,626	3,074
2643	1,886	2,183	2,867	2,980	3,379
2645	676	747	923	943	1,027
2649	631	833	1,079	1,090	1,288
2651	1,487	1,644	1,890	1,952	2,223
3291	888	1,067	1,235	1,222	1,433
3292	763	823	963	900	988
3293	665	723	835	843	1,020
3499	702	753	973	1,065	1,267
3679	3,060	3,430	3,210	3,450	4,120
3842	1,450	1,620	1,800	2,090	2,240
3861	5,624	6,435	7,490	7,627	8,844
3955	237	268	309	285	294
Total	31,271	36,035	42,400	44,408	51,744

Source: 1976 Annual Survey of Manufactures, U.S. Department of Commerce.

2.3 TECHNICAL SITUATION IN THE INDUSTRY

This section briefly describes the general process and materials used in the surface coating of paper and similar products proposed to be included under the RACT Surface Coating of Paper limitations. The technology is fully described in the RACT documents.[1] The products include a myriad of consumer and industry oriented items, such as pressure-sensitive tapes, adhesive labels, book covers, milk cartons, flexible packaging materials and photographic film. Although many of these products are also printed in one manner or another, the emissions from printing inks are not included in the RACT regulations pertaining to paper coating; only the emissions specifically issuing from the coating operation are included. An estimate of these emissions for the state is presented in this section.

2.3.1 General Coating Process Description

In organic solvent paper coating, resins are dissolved in an organic solvent mixture and this solution is applied to a web (continuous roll) of paper. As the coated web is dried, the solvent evaporates and the coating cures.

Most organic solventborne coating is done by paper converting companies that buy paper from the mills and apply coatings to produce a final product. The paper mills themselves sometimes apply coatings, but these are usually waterborne coatings consisting of a pigment (such as clay) and a binder (such as starch or casein). However, much additional coating is done by firms only as part of the manufacturing process.

Solvent emissions from an individual coating facility will vary with the size and number of coating lines. A plant may have one or as many as 20 coating lines. Uncontrolled emissions from a single line may vary from 50 pounds per hour to 1,000 pounds per hour, depending on the line size. The amount of solvent emitted also depends on the number of hours the line operates each day.

Exhibit 2-4, on the following page, gives typical emission data from various paper coating applications.

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[1] Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II, EPA-450/2-77-008

EXHIBIT 2-4
U.S. Environmental Protection Agency
EMISSION DATA FROM TYPICAL PAPER COATING PLANTS

Number of Coating Lines	Solvent Usage (lb./day)	Solvent Emissions (lb./day)	Control Efficiency (%)[a]	Control Device
2	10,000	10,000	-	None
5	15,000	15,000	-	None
8	9,000	9,000	-	None
2	1,200	1,200	-	None
10	24,000	950	96	Carbon adsorption
20	55,000	41,000	90	Carbon adsorption (not all lines controlled)
3	5,000	1,500	90	Carbon adsorption
3	21,000	840	96	Carbon adsorption
1	10,500	500	96	Afterburner

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[a] Neglecting emissions that are not captured in the hooding system.

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. II, EPA-450/2-77-008.

2.3.2 Nature of Coating Materials Used

The formulations usually used in organic solventborne paper coatings may be divided into the following classes: film-forming materials, plasticizers, pigments and solvents. Dozens of organic solvents are used. The major ones are: toluene, xylene, methyl ethyl ketone, isopropyl alcohol, methanol, acetone and ethanol.

Although a single solvent is frequently used, often a solvent mixture is necessary to obtain the optimum drying rate. Too rapid drying results in bubbles and an "orange peel" effect in the coating; whereas, slow drying coatings require more time in the ovens or slower production rates. Variations in the solvent mixture also affect the solvent qualities of the mix.

The main classes of film formers used in conventional paper coating are cellulose derivatives and vinyl resins. The most commonly used cellulose derivative, nitrocellulose has been used for paper coating decorative paper, book covers and similar items since the 1920s. It is relatively easy to formulate and handle, and it dries quickly, allowing lower oven temperatures than vinyl coatings. The most common vinyl resin is the copolymer of vinyl chloride and vinyl acetate. These vinyl copolymers are superior to nitrocellulose in toughness, flexibility and abrasion resistance. They also show good resistance to acids, alkalies, alcohols and greases. Vinyl coatings tend to retain solvent, however, so that comparatively high temperatures are needed. In general, nitrocellulose is most applicable to the decorative paper field, whereas vinyl copolymers are used for functional papers, such as some packaging materials.

In the production of pressure-sensitive tapes and labels, adhesives and silicone release agents are applied using an organic solvent carrier. The adhesive layer is usually natural or synthetic rubber, acrylic or silicone. Because of their low cost, natural and synthetic rubber compounds are the main film formers used for adhesives in pressure-sensitive tapes and labels, although acrylic and silicone adhesives offer performance advantages for certain applications. In most cases, tapes and labels also involve the use of release agents applied to a label carrier or the backside of tape to allow release. The agents are usually silicone compounds applied in a dilute solvent solution.

2.3.3 Current VOC Emissions

This section presents the estimated VOC emissions from paper coating operations in Massachusetts for the year 1976. A summary of applicable emissions for the paper coating RACT category is presented in Exhibit 2-5, on the following page. Plants listed are believed to represent the major single sources of emissions in the state and in total represent the major portion of paper coating emissions.

Applicable current emissions from paper coating in Massachusetts are approximately 11,000 tons per year. Potential emissions are approximately 22,500 tons per year. This figure is based on plant-by-plant data in Massachusetts files and on an exhaustive telephone survey of companies expected to be affected by the regulations.

Approximately 10,900 tons per year are from ten plants with potential emissions greater than 100 tons per year (because emissions from some of those firms are already partially controlled, about 10,600 tons per year are applicable to further control under RACT), 45 tons per year from two plants with potential emissions between 25 and 100 tons per year, and 55 tons per year from one plant located in a "rural" area (potential emissions are less than 100 tons per year).

2.3.4 RACT Guidelines

The RACT guidelines for control of VOC emissions from the surface coating of paper require that emission discharges of VOCs be limited to 2.9 pounds per gallon of coating material delivered to the coating applicator.

The recommended methods of achieving this requirement are:

- The application of low solvent content coatings; or
- Incineration, provided that 90 percent of the nonmethane VOCs (measured as combustible carbon) which enter the incinerator are oxidized to carbon dioxide and water; or
- A system demonstrated to have control efficiency equivalent to or greater than provided by either of the above methods.

Exhibit 2-5

U.S. Environmental Protection Agency

COMPANY ESTIMATES OF PAPER COATING EMISSIONS IN MASSACHUSETTS

		Company Name Location	SIC Code	Employees	Potential Emissions	Applicable Paper Coating Emissions without Control (tons per year)	Control System	Applicable Paper Coating Emissions with Current Controls (tons per year)
Coaters Directly Affected	Potential Emissions Greater Than 100 TPY	BASF Systems Bedford	3861	3,150	a	1,258	carbon[b] adsorption	198
		Custom Coating & Laminating Co. Worchester	3079	20	185	95	none	95
		Dennison Manufacturing Company Framingham	2649	2,500	9,746	4,450	carbon adsorption	3,249[c]
		James River-Fitchburg, Inc. Fitchburg	2621	131	1,615	1,615	incineration	242[d]
		James River-Mass., Inc. Fitchburg	2621	168	3,480	2,860	none	2,860
		Le Pages, Inc. Gloucester	2641	150	2,447	1,667	none	1,667
		National Coating Corporation Rockland	3079	15	334	76	none	76
		Phillips Clemtex International Newburyport	2641	35	236	157	none	157
		Polaroid Corporation Waltham	3861	530	2,912	2,281	none	2,281
		Republic Foil Somerville	2643	100	107	77	none	77
	Potential Emissions Between 25 & 100 TPY	Bird & Son, Inc. Walpole	2952	180	35	14	none	14
		Polaroid Corporation Cambridge	3861	3,150	68	31	none	31
Use Low Solvent Coatings Or Located In Rural Area		Container Corporation of America Medford	2651	220	-	e	none	-
		M.B. Claff & Sons Brockton	2651	200	-	e	none	-
		Polaroid Corporation[f] New Bedford	3861	610	78	55	none	55
		St. Regis Paper Company Newton	2641	375	-	e	none	-
		Sweetheart Paper Products, Inc. Chelsea	2654	395	-	e	none	-
				11,929	~22,500	14,636		11,002

a. Not reported.

b. Emissions only partially controlled by carbon adsorption. Uncontrolled emissions are 8 tpy; the remaining 190 tons are residuals from controls.

c. Emissions only partially controlled by carbon adsorption. Uncontrolled emissions are 3,221 tpy; the remaining 25 tons are residuals from controls.

d. Emissions only partially controlled by incineration. Uncontrolled emissions are 170 tpy; the remaining 52 tons are residuals from controls.

e. These firms use water-based or other low solvent coatings exclusively. The VOC emissions which come from this process were not reported.

f. This firm is in a rural area where only those plants with potential emissions greater than 100 tons per year are affected.

Source: Booz, Allen & Hamilton Inc.

In the following section are discussed several methods of low solvent and solventless systems, which have been demonstrated to be applicable to some paper coating products, and the two principal add-on systems, incineration and carbon adsorption, generally used for emission control. This information has been extracted principally from the previously cited EPA report, Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-77-008), which should be consulted for a more thorough discussion. In some instances, additional information was obtained from coaters, coating material suppliers and control equipment manufacturers.

2.3.5 Low Solvent and Solventless Coatings

In Exhibit 2-6, on the following page, are listed several types of coating materials which have found utility in paper coating, and an estimate of expected solvent reduction.

2.3.5.1 Waterborne Coatings

Waterborne coatings have long been used in coating paper to improve printability and gloss. However, newer coatings have been developed in which a synthetic insoluble polymer is carried in water as a colloidal dispersion or an emulsion. This is a two-phase system in which water is the continuous phase and the polymer resin is the dispersed phase. When the water is evaporated and the coating cured, the polymer forms a film that has properties similar to those obtained from organic-solvent-based coatings.

2.3.5.2 Plastisols and Organisols

Plastisols are a colloidal dispersion of synthetic resin in a plasticizer. When the plasticizer is heated, the resin particles are solvated by the plasticizer so that they fuse together to form a continuous film. Plastisols usually contain little or no solvent, but sometimes the addition of a filler or pigment will change the viscosity so that organic solvents must be added to obtain desirable flow characteristics. When the volatile content of a plastisol exceeds 5 percent of the total weight, it is referred to as an organisol.

EXHIBIT 2-6
U.S. Environmental Protection Agency
ACHIEVABLE SOLVENT REDUCTIONS USING LOW SOLVENT COATINGS IN PAPER COATING INDUSTRY

Type of Low Solvent Coating	Reduction Achievable (%)[a]
Waterborne coatings	80-99
Plastisols	95-99
Hot melts	99+
Extrusion coatings	99+
Pressure-sensitive adhesives	
Waterborne	80-99
Hot melts	99
Prepolymer	99
Silicone release agents	
100 percent nonvolatile coatings	99+
Waterborne emulsions	80-99

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[a] Based on comparison with a conventional coating containing 35 percent solids by volume and 65 percent organic solvent by volume.

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II, EPA-450/2-77-008.

Although organic solvents are not evaporated from plastisols, some of the plasticizer may volatilize in the oven. This plasticizer will condense when emitted from the exhaust stack to form a visible emission.

2.3.5.3 Hot Melt Coatings

Hot melt coatings contain no solvent; the polymer resins are applied in a molten state to the paper surfaces. All the materials deposited on the paper remain as part of the coating. Because the hot melt cools to a solid coating soon after it is applied, a drying oven is not needed to evaporate solvent or to cure the coating. Energy that would have been used to heat an oven and to heat makeup air to replace oven exhaust is therefore saved.

One disadvantage with hot melt coatings is that materials that char or burn when heated cannot be applied by hot melt. Other materials will slowly degrade when they are held at the necessary elevated temperatures.

2.3.5.4 Extrusion Coatings

A type of hot melt coating, plastic extrusion coating is a solventless system in which a molten thermoplastic sheet is discharged from a slotted dye onto a substrate of paper, paperboard or synthetic material. The moving substrate and molten plastic are combined in a nip between a rubber roll and a chill roll. A screw-type extruder extrudes the coating at a temperature sometimes as high as 600°F. Low and medium density polyethylene are used for extrusion coating more than any other types of resins.

2.3.5.5 Pressure-Sensitive Adhesive Coatings

Waterborne adhesives have the advantage that they can be applied with conventional coating equipment. Waterborne emulsions, which can be applied less expensively than can solventborne rubber-based adhesives, are already in use for pressure-sensitive labels. A problem with waterborne adhesives is that they tend to cause the paper substrate to curl and wrinkle.

Prepolymer adhesive coatings are applied as a liquid composed of monomers containing no solvent. The monomers are polymerized by either heat or radiation. These prepolymer systems show promise, but they are presently in a developmental stage only.

2.3.5.6 Silicone Release Coatings

Silicone release coatings, usually solventborne, are sometimes used for pressure-sensitive, adhesive-coated products. Two low-solvent alternatives are currently on the market. The first is a 100 percent nonvolatile coating which is usually heat cured, but may be radiation cured. The second system is a water emulsion coating which is lower in cost than the prepolymer coating. However, because of wrinkling and other application problems the waterborne coating may be of limited value.

Some silicone coating materials which are under development use single solvent systems that can be readily recovered by carbon adsorption. Current coatings are troublesome since some silicone is carried into the adsorber where it clogs the carbon pores to reduce adsorption efficiency.

2.3.6 Incineration

Catalytic and direct thermal incineration processes convert hydrocarbons to carbon dioxide and water at high temperatures. Incineration is widely accepted as a reliable means of reducing hydrocarbon emissions by 90 percent or more.

Generally, the major disadvantage of this approach is the increased energy required to raise the exhaust gas temperatures above 1,200°F for direct incineration and 700°F for catalytic incineration. Another problem is the generation of nitrogen oxides in direct fired incinerators because of the exposure of air to high-temperature flames.

The increased energy consumption can, in some cases, be reduced or eliminated by heat exchange of the exhaust gases with fresh emissions (primary heat recovery) or by use of the hot incinerator exhaust gases in process applications (secondary heat recovery). Typical use of secondary heat recovery is for oven heat in drying or baking ovens. In fact, with efficient primary exchange and secondary heat recovery, total fuel consumption of an incinerator-oven system can be less than that for the oven before the incinerator is added. The heat required to sustain the system comes from the combustion of the volatile organic compounds in the exhausts.

Paper coaters who use coating machinery for a multiplicity of processes have commented that catalytic incineration would probably not be used because of the possibility of catalyst poisoning. Direct incineration would be used.

2.3.7 Carbon Adsorption

Carbon adsorption has been used since the 1930s for collecting solvents emitted from paper coating operations. Most operational systems on paper coating lines were installed because they were profitable. Pollution control has usually been a minor concern.

Carbon adsorption is most adaptable to single solvent processes. Many coaters using carbon adsorption have reformulated their coatings so that only one solvent is required. Toluene, a widely used solvent for paper coating, is readily captured in carbon adsorption systems.

The greatest obstacle to the economical use of carbon adsorption is that, in some cases, reusing recovered solvents may be difficult. In many coating formulations, a mixture of several solvents is needed to attain the desired solvency and evaporation rates. Also if different coating lines within the plant use different solvents and are all ducted to one carbon adsorption system, then there may be difficulty reusing the collected solvent mixture. In some cases, such as in the preparation of photographic films or thermographic recording paper, extremely high purity solvents are necessary to maintain product performance and even distillation may be insufficient to produce the quality of recovered solvent needed. For most other coating formulations, distillation is adequate.

Another problem with carbon adsorption is the potential of generating explosive conditions in the adsorber because of the localized increases in combustible organic material concentrations. Ignition apparently can be caused by static electricity in systems where dry air at high flow rates is treated. Several explosions of absorbers have been reported in paper coating and other plants.

Also, adsorption of solvents containing water soluble compounds (such as alcohols, ketones or esters) can present a secondary pollution problem in the water effluent, where steam is used for regeneration. Additional treatment of the condensed steam with its content of dissolved organics would be required, increasing the complexity of the solvent recovery system and its cost.

2.4 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

This section discusses the projected costs of control for paper coating in the state based on the emissions as discussed in Section 2.3.3 of this report. Where possible, the validity of the costs were confirmed with coating firms and equipment manufacturers.

Where possible, coaters in Massachusetts have already switched to water-based or low solvent systems. Two are using water-based coating materials exclusively and two are using hot melt systems. Other firms reported that planned expansions will add only coating systems which meet the proposed requirements. Nearly all coating firms are working to develop low solvent coating materials.

Based partly on statements made by officials of the directly affected firms, it has been assumed, for cost estimation purposes, that these firms will use incineration or carbon adsorption to control their emissions. One of the firms, which already has a control system for part of its coating lines, will not incur significant additional capital cost to control remaining lines. This firm supplied an accurate estimate of their increased operating cost.

2.4.1 Costs of Alternative Control Systems

Carbon adsorption and incineration system costs were derived from cost correlations given in EPA-450/2-76-028. The cost estimates for both systems are based on the assumption that exhaust air flow rates can be reduced sufficiently to attain lower explosion limit (LEL) levels of 25 percent. This is possible with well-designed ovens where excess air can be reduced or where product characteristics allow. Lower LEL levels require higher air flow and thus result in higher control costs.

Several paper coaters indicate that achieving 25 percent of LEL may not be possible with some coating lines, particularly older ones, or with certain types of coatings. Coating drying rate is a function of air flow rate, temperature and vapor concentration in the air. If air flow rates are to be reduced, drying temperatures or drying times must be increased. Because of the heat sensitivity of some coatings, temperature increases may not be possible. Increase in drying time will necessitate either longer ovens or reduced production rates. Several coaters of heat sensitive products indicated that, to achieve special characteristics, they could not increase emission concentrations above 5 to 6 percent of LEL and could not use oven temperatures above 140°F. Plants manufacturing conventional coated products, however, can decrease air flow rates sufficiently to increase VOC concentrations in the exhausts to 40-50 percent of LEL with only moderate increases in temperatures or changes in production rates. For purposes of cost estimation in this report, it has been assumed that 25 percent of LEL can be achieved on the average. A more detailed analysis would require an in depth survey and study of the types of coatings and allowable LEL operation levels. In many cases it is expected that processes can be modified to operate at this level with the simple addition of LEL control systems.

Incinerator costs are a function of equipment size, which varies generally with air flow rate. In most plants, it is impractical to manifold exhausts so that all exhausts could be treated in one add-on emission control system. Also, it would be difficult to use secondary heat recovery on ovens where the incinerator is remote from the oven.

The major problem in estimating total installed costs of control systems is the cost of installation. The Booz, Allen estimates were made on the assumption of a moderately difficult retrofitted system, i.e., one that requires considerable tailoring of the design and modification of connected and nearby equipment. Commonly, coaters have found actual installed costs to be three to five times those presented in the EPA document referred to earlier.

In order to illustrate the range costs which an individual coater may experience, Exhibit 2-7, on the following page, tabulates the costs for incinerator and carbon adsorption systems for two air flow rates, 2,000 SCFM and 15,000 SCFM. These are equivalent to solvent emission rates of about 100 tons and 750 tons respectively per year for the operating parameters noted in the exhibit. Of particular significance is the range of cost effectiveness encountered which indicates major economies of scale.

2.4.2 Estimated Statewide Costs

The total emissions considered to be applicable under RACT, as discussed in Section 2.3.3 of this report, are about 10,600 tons per year for the ten directly affected firms with potential emissions greater than 100 tons per year. These firms have evaluated alternative control methods and would probably select an incineration

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EXHIBIT 2-7
U.S. Environmental Protection Agency
COST FOR A TYPICAL ADD-ON CONTROL SYSTEM

Control Device	Installed Cost	Annualized Cost	Cost Effectiveness Annualized Cost/ Emission Reduction
Incinerator, primary heat recovery			
2,000 SCFM	385,000	100,000	1,000
15,000 SCFM	525,000	136,000	180
Carbon adsorber, recovered solvent credited at market value			
2,000 SCFM	426,000	77,000	770
15,000 SCFM	1,300,000	189,000	250
Carbon adsorber, no credit given for recovered solvent			
2,000 SCFM	426,000	117,000	1,200
15,000 SCFM	1,300,000	387,000	520

Note: These costs are based on an air emission containing 25 percent of LEL volatile organic content; oven temperature of 300°F for incineration and 375°F for carbon adsorption and operating time of 2,000 hours per year. Other assumptions are as tabulated in EPA-450/2-76-028, Tables 4-3 and 4-8 except capital costs are multiplied by 3.5 to account for common retrofit situations which may include modifications to improve collection.

Source: Booz, Allen & Hamilton Inc. revisions of data in EPA-450/2-76-028 system or carbon adsorption system since in most cases low solvent systems are not currently available or would cost more to use.

Total costs of compliance are based on 7,100 tons per year of emissions being reduced by incineration and 3,500 tons per year of emissions being reduced by carbon adsorption.

The air flow rates for each of the affected firms were determined on the assumption of a 25 percent approach to LEL, other assumptions summarized in Exhibit 2-8, on the following page, and each firm's current estimated emissions. These air flow rates were then used to estimate costs from EPA-450/2-76-028.

By applying these factors, and the cost estimating procedures in EPA-450/2-76-028, the capital costs were estimated to be $2.2 million, with annualized costs of $82,000 with recovered solvent credited at market and $690,000 with no credit. These were adjusted for inflationary increases from mid-1975 (base period for EPA-450/2-76-028 data) to mid-1977 at a rate of 8 percent per year.[1]

However, discussions with equipment manufacturers and coaters and review of published information indicated that these capital costs are probably three to four times lower than those experienced in recent, moderately difficult, retrofit situations. This issue is also addressed in EPA-450/2-76-028, which indicated that baseline capital costs could be 1.5 to 3 times higher because of various retrofit difficulties.

Therefore, assuming a three to four multiplier for capital costs, it is estimated that actual capital costs for the state are more likely to range from $6.6 million to $8.7 million with corresponding annualized costs of $1.2 million to $1.7 million with recovred solvent credited at market value and $2.0 million to $2.6 million with no credit. These figures are utilized in the remainder of the report. An example of the complete calculation procedures for a sample plant is presented in the appendix to this report.

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[1] Based on Chemical Engineering magazine's process equipment cost indices for mid-1975 and mid-1977.

EXHIBIT 2-8
U.S. Environmental Protection Agency
SUMMARY OF ASSUMPTIONS USED IN COST ESTIMATE FOR PAPER COATING IN MASSACHUSETTS

Assumptions

7,100 tons of emissions are controlled by incineration with primary heat recovery; 3,500 tons by carbon adsorption[a] with recovered solvent credited at market value or where noted with no credit.

25 percent LEL is equal to 4,250 ppm of toluene by volume.

Air flow can be reduced to reach 25 percent LEL.

For the carbon adsorption systems no costs are added for distillation or additional waste disposal. All costs were derived from EPA-450/2-76-028.

The emissions are treated over operating periods specified by each firm.

Other assumptions regarding incinerator and adsorber operating factors estimated in *Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. I: Control Methods for Surface-Coating Operations*, EPA-450/2-76-028, are valid.

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[a] This split is based on statements made by officals of the affected firms.

Source: Booz, Allen & Hamilton Inc.

If Massachusetts choses to reduce their emissions limit to 25 tons per year in urban areas, two additional firms would be affected and the actual statewide capital costs would increase to $7.4 million to $9.7 million with the installation of incinerators. Corresponding annualized costs would increase to $1.4 million to $2.0 million with recovered solvent credited at market value and $2.2 million to 2.9 million with no credit.

The capital costs to individual firms are estimated to vary from about $380,000 to about $2,000,000. In the case of the lowest capital investment, annualized costs would be about $100,000 for the operation of an incinerator. In the case of the highest investment for the installation of two carbon adsorbers total annualized costs would be $230,000 with recovered solvent credited at market value and $550,000 with no credit.

2.5 DIRECT ECONOMIC IMPACTS

This section presents the direct economic implications of the RACT guidelines for surface coating of paper on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost pass-through), state economic variables and capital investment.

2.5.1 RACT Timing

Current proposed guidelines for paper coating suggest several compliance deadlines for alternative methods of compliance.[1] Generally, for add-on systems, they call for installation of equipment and demonstration by mid-1980 or late 1980; for low solvent systems, by late 1980 or mid-1981, depending upon the degree of research and development needed. Major coaters, material suppliers and equipment manufacturers believe these deadlines to be unattainable if all states adopt similar requirements at the same time.

- Normally, large incinerator and carbon adsorption systems will require about a year or more from receipt of purchase order to install and start up the system. Engineering may require three months or more, fabrication three to six months and installation and startup as long as three months.
- Only a few companies manufacture incineration systems with proven high heat recovery. The cumulative effect of equipment requirements by all firms in the U.S. needing control devices could severely impede the ability of these firms to supply equipment. In some cases, the most efficient devices are only now undergoing initial trials, and no production capacity has been developed.

In general, it appears that if add-on control systems are used, deadlines may have to be extended, based on an analysis of the effects of a combined national demand.

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[1] Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001, April 1978.

2.5.2 Technical Feasibility Issues

Though low solvent or solventless materials are used in many paper coating operations at present and though some firms are using these materials exclusively, many types of solvent-based systems currently have no satisfactory replacement. In many cases, the alternative materials do not meet the product quality standards demanded by the coaters and their customers. Additional development is needed and will require the combined efforts of both the coaters (who must maintain finished product quality) and the coating material suppliers. While the time required to develop the low solvent materials is difficult to estimate, it is unlikely that new coatings can be commercialized by 1981. Ideally, the new coating materials should be adaptable to existing coating equipment to minimize additional capital investment.

As discussed above, both incineration and carbon adsorption are not completely satisfactory add-on control systems. Incineration requires large volumes of additional fuel if good heat recovery is not accomplished; carbon adsorption is not usable on many coating systems because of the multiplicity of compounds used in solvent mixtures.

Many coaters in Massachusetts have indicated that it would not be reasonable for them to install an add-on control system at a time when low solvent systems for wider application are two to three years away from commercial development. Perhaps where low solvent systems are practical, but not currently available, up to five years should be allowed for development since this would be considered to be innovative technology.

2.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

The net increase in annualized costs to coaters was estimated at $1.2 million to $1.7 million. These additional costs are projected to represent 0.16 to 0.23 percent of the total annual value of shipments of the 17 firms coating paper in Massachusetts and 0.22 to 0.31 percent of the total shipments of the ten firms directly impacted by the proposed regulations. Assuming a "direct passthrough" of these costs, prices at these ten firms would be expected to increase by 0.22 to 0.31 percent. (In terms of the total value of all manufacturing shipments in Massachusetts these costs represent 0.004 to 0.006 percent.)

For individual firms it was estimated that annualized compliance costs would range from about 0.04 to about 0.40 percent of the total annual value of shipments. This estimate was based on an approximate calculation of the value of shipments of firms with the lowest and highest expected annualized compliance costs and should be used only for comparative purposes. The value of shipments was calculated simply by using an average value of shipments per employee based on the data for SIC groups tabulated in Exhibit 2-2 of this report.

The use of a price increase based on a "direct pass-through" as estimated above should be interpreted with caution since it employs the total value of shipments. In many cases, paper coated products represent only a portion of the shipments of these firms. If the compliance costs were applied only to those products affected by the regulations, the cost and in turn the price impacts could be significantly higher.

For an example, one Massachusetts firm, which will incur a low cost of control relative to its total annual value of shipments, commented that the annual operating cost of compliance alone will result in a 22 percent cost increase on a major product line. Pricing for this product is highly competitive and the firm may be forced to terminate this operation.

The major economic impact in terms of cost to most individual companies will be the large capital expenditures required for add-on devices, rather than the increased annualized costs. For most companies, these costs would exceed their normal level of capital expenditures for plant improvement and expansion curbing prospective growth of the firm. A large pressure-sensitive paper coater in another state, for instance, has estimated that a capital investment of about $2 million would be needed to meet proposed guidelines. His current annual capital expenditure program is normally in the range of $1.5 million.

Another typical case is an out-of-state firm which manufactures various types of recording paper. Although, with additional development, some of its coating solutions could be replaced with low solvent or waterborne ones, incineration or carbon adsorption would be the only method of complying with the regulation as now proposed. Based on projected costs for either of these add-on control systems, the firm is seriously considering terminating or moving operations. Similar financial difficulties are foreseen for marginally profitable firms which have limited capital access or for which the added annual costs of compliance are prohibitive.

The capital investments required to install the control equipment are several times larger than the normal annual capital expenditure of some Massachusetts paper coaters. Since some of these plants may be privately owned, raising the necessary capital for the control systems could be difficult. In confirmation of these observations, several Massachusetts firms commented in the interviews that if compliance costs, both capital and annualized, were as projected that they may indeed be forced to terminate operations.

2.5.4 Selected Secondary Economic Impacts

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

Total statewide employment is not expected to be affected significantly. However, if some marginally profitable plants close or terminate paper coating lines there may be an effect on local employment. One of the firms reportedly may be faced with shortening their workweek from six to four days or laying off up to 50 people.

Because the effect of annualized costs on smaller firms is more pronounced due to the economies of scale characteristic of add-on control systems, closures of smaller firms are possible because they can no longer be competitive in price.

No significant effect on overall productivity is foreseen, except for a small change resulting from the need for add-on control system operating and maintenance personnel. This may be compensated for by small increases in productivity in firms that gain business from those which close rather than meet the RACT requirements.

2.5.5 Impact of Compliance Upon Energy Consumption

Based on the assumption that 7,100 tons of affected emissions would be controlled by installation of direct fired incinerators with primary heat recovery (at 35 percent efficiency) and 3,500 tons by carbon adsorption, energy consumption is expected to increase by an amount equal to approximately 20,000 barrels of oil annually. This is equivalent to approximately 160 million cubic feet of natural gas annually. The estimate is based on the assumptions that oven exhausts are about 300?F, that about 8 pounds of steam are used per pound of solvent recovered and that a barrel of oil is equivalent to 6.0 x 106 BTUs.

* * * *

Exhibit 2-9, on the following page, summarizes the conclusions reached in this study and the implications of the estimated costs of compliance for paper coaters.

EXHIBIT 2-9(1)
U.S. Environmental Protection Agency
SUMMARY OF FINDINGS IN THE STUDY OF THE DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR PAPER COATERS IN THE STATE OF MASSACHUSETTS

Current Situation	Discussion
Number of potentially affected facilities	Ten plants in the state are expected to be directly affected by these regulations at the 100 TPY limitation. Two additional plants may be affected at the 25 TPY limit. However, if this category were to be interpreted to include all types of paper coating, including publishing, far more firms would be affected.
Indication of relative importance of the industrial sector to state company	The 1977 value of shipments of these ten plants is estimated to be about $540 million. They are estimated to employ 6,800 people.
Current industry technology trends	Gravure coating replacing older systems. A major effort is underway to develop low solvent systems.
1977 VOC emissions (actual) applicable under RACT	Approximately 10,900 tons per year were identified from ten plants potentially affected. Total industry emissions from all identified plants is 11,000 TPY.
Industry preferred method of VOC control to meet RACT guidelines	Many coaters are using some water-based coating materials. Add-on control systems will probably be used by some coaters.
Assumed method of control to meet RACT guidelines	Thermal incineration with primary heat recovery and carbon adsorption.

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Estimated to be $6.6 million to $8.7 million depending on retrofit situations. This is likely to be more than 100 percent of normal expenditures for the affected paper coaters.

EXHIBIT 2-9(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
Annualized cost (statewide)	$1.2 million to $1.7 million annually. This may represent 0.16 to 0.23 percent of the 1977 total annual value of shipments for the 17 potentially affected paper coaters and 0.22 to 0.31 percent of the total value of shipments for the ten firms directly affected. For individual firms, the cost ranges from 0.04 to 0.4 percent to the value of shipments.
Price	Assuming a "direct cost pass-through" based upon the estimated total value of shipments of the 10 firms affected a 0.20 to 0.30 percent increase in price may occur.
Energy	Assuming 35 percent heat recovery, annual energy requirements are expected to increase by approximately 20,000 equivalent barrels of oil.
Productivity	No major impact.
Employment	No major impact upon statewide employment is likely to occur. However, some small individual firms may be forced to terminate operations.
Market structure	Marginal firms may be forced into moving or terminating certain product lines.

EXHIBIT 2-9(3)
U.S. Environmental Protection Agency

RACT timing requirements (1982)	RACT guideline needs precise definition with respect to what processes are included for enforcement. Equipment deliverables and installation of incineration systems prior to 1982 are expected to present problems. Development of low solvent systems is likely to extend beyond 1982.
Analytical difficulties	Installation costs in retrofit situations are highly variable. Type and cost of control depend on particular solvent systems used and reduction in air flow.
VOC emissions after control	Approximately 2,010 tons/year (19 percent of uncontrolled emissions from the ten affected plants and 21 percent of 1976 emission level for the 17 firms coating paper).
Cost effectiveness of control	Annualized cost/annual ton of VOC reduction is in the range of $135 to $190 based on average of the total annualized costs for the plants affected and the total emission reduction expected (81 percent). Individual plants, however, could have costs as high as $1,600 per ton of annual emissions reduced.

Source: Booz, Allen & Hamilton Inc.

3.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING FABRICS IN THE STATE OF MASSACHUSETTS

3.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING FABRICS IN THE STATE OF MASSACHUSETTS

This chapter presents a detailed analysis of the impact of implementing RACT for plants in the State of Massachusetts which are engaged in the surface coating of fabrics and vinyls. This RACT category is meant to include the roll, knife or rotogravure coating and oven drying of textile fabrics (to impart strength, stability, appearance or other properties), or of vinyl coated fabrics or vinyl sheets. It includes printing on vinyl coated fabrics or vinyl sheets to modify appearance but not printing on textile fabrics for decorative or other purposes. It also does not include impregnation of fabrics and the coating of fabric substrates with vinyl plastic polymers, which are usually applied as melts or plastisols, that result in only minor amounts of emissions. Dip coating of fabrics is also excluded unless such coating can normally be applied using knife or roller.

The economic impact assessment is based on the proposed regulation which would affect facilities with potential VOC emissions over 100 tons per year. This same assessment would apply if the regulations were revised to include facilities with potential VOC emissions over 25 tons per year in urban areas, as no facilities were identified with potential VOC emissions between 25 to 100 tons per year in the designated urban areas of Massachusetts. The chapter is divided into six sections:

- Specific methodology and quality of estimates
- Industry statistics
- Technical situation in the industry
- Alternative control methods
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines; previous studies of fabric coating; interviews with fabric and vinyl coaters, coating equipment and materials manufacturers and add-on control equipment manufacturers, and a review of pertinent published literature.

3.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Economic impacts

for plants in the state engaged in the surface coating of fabrics and vinyls. The quality of these estimates is discussed in the last part of this section.

3.1.1 Industry Statistics

The coating of fabrics is used to produce a large variety of common consumer and industrial products. Typical products are raincoats, upholstery, wall covering, tablecloths, window shades, gasketing, diaphragms, lifeboats and bookcovers. In most cases, the finished product is manufactured by firms who purchase the coated fabric from a manufacturer, whose principal activity is fabric coating. However, there are a number of vertically integrated firms (the major automobile manufacturers are typical) which both coat fabrics and manufacture finished goods from them. Also examples are firms which both manufacture fabrics and coat them. Thus, firms which coat fabrics or vinyl coated fabrics or sheeting can be found in a number of Standard Industrial Classification categories; these are listed below:

SIC	Description
2211	Broad woven fabric mills, cotton
2221	Broad woven fabric mills, man-made and silk
2241	Narrow fabrics and other, small wares mills
2258	Warp knit fabric mills
2261	Finishers of broad woven fabrics of cotton
2262	Finishers of broad woven fabrics of man-made fiber and silk
2269	Finishers of textiles, n.e.c.*
2295	Coated fabrics, not rubberized
2297	Nonwoven fabrics
3069	Fabricated rubber products, n.e.c.*

*not elsewhere classified

3079	Miscellaneous plastics products
3291	Abrasive products
3293	Gaskets, packing, sealing devices

General statistics concerning the firms included in these SIC groupings were obtained from the most recent Census of Manufactures, County Business Patterns and other economic summaries published by the U.S. Department of Commerce. Data on industrywide shipments of coated fabrics were obtained from the Textile Economics Bureau (New York, New York).

Identification of individual candidate firms which might be affected by the proposed regulation was made in two steps:

- First, the Department of Environmental Quality Engineering of the Commonwealth of Massachusetts compiled a preliminary list of 37 firms potentially affected by the proposed regulations. Data on the emissions, number of employees, operating hours and controls at those potentially affected facilities were also compiled.
- The Booz, Allen study team then conducted telephone interviews with each of these firms to verify its inclusion in the RACT industrial category and other information as discussed in Section 2.1.4 of this report.

Based on the information obtained during the industry interviews and the data provided by the state, only 24 firms were found to perform fabric coating as defined in the proposed regulations. The remaining 13 firms were found not to be affected by the proposed regulations because they did not perform fabric coating as defined in the proposed regulations.[1] These 13 firms are cited in Exhibit 3-1, on the following page, and the potentially affected firms are listed in section 3.2.

3.1.2 VOC Emissions

Emissions data compiled by the Massachusetts Department of Environmental Quality Engineering were used as the basis for the estimation of the total VOC emissions from the fabric coating plants identified. This data

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[1] As proposed in Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-950/2-78-001, April, 1978.

EXHIBIT 3-1
U.S. Environmental Protection Agency
LIST OF FACILITIES NOT INCLUDED IN THE ANALYSIS OF RACT REGULATIONS FOR FABRIC COATING OPERATIONS

FIRM	LOCATION	COMMENT
Attleboro Dyeing & Finishing	Seekonk	No coating, only finishing
Globe Manufacturing Co.	Fall River	No fabric coating
Durofinishing Corp.	Fall River	No fabric coating
Robinson Thread Co.	Worcester	No fabric coating
Cranston Print Works	Webster	No coating, only printing on textile fabrics
Creese & Cook, Inc	Danvers	Work with natural leather only
National Tanning & Trading Corp.	Peabody	Work with natural leather only
Beverly Leather Co.	Salem	Work with natural leather only
Bixby International	Haverhill	Perform impregnation and hot melt adhesive coating
ESB, Inc. - Granite Division	Framingham	Perform dip coating of cotton gloves
Dodgeville Corp.	Attleboro	No fabric coating
Swan Finishing Co., Inc	Fall River	No fabric coating
Arkwright Finishing	Fall River	No fabric coating

Note: These firms were on the preliminary list of potentially affected firms compiled by the Massachusetts Department of Environmental Quality Engineering and were interviewed by Booz, Allen study team.

Source: Booz, Allen & Hamilton Inc.

base included information on types and efficiency of current controls, which was refined during the industry interviews. The estimated total emissions are believed to represent 90 percent or more of the emissions in this RACT category. Emissions from other fabric coating plants not identified by the state, if they exist, are expected to be small in terms of VOC emissions accounted for in this analysis.

3.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from fabric coating processes are described in Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-77-008). The feasibility of applying the various control methods to fabric coating presented in this document was reviewed with coating firms, coating suppliers, coating equipment manufacturers and industry associations. These methods include both coating reformulation and the use of control devices, such as incinerators and carbon adsorbers.

Because of the wide variety of coating processes and coating materials in use, most methods of control will find some applicability. The situations where emissions are likely to be controlled by reformulation and by control devices were estimated, based on a review of the literature and on information obtained from interviews.

3.1.4 Cost of Control and Estimated Reduction of VOC Emissions

The overall costs of control of VOC emissions to meet the proposed regulations were determined from:

Generalized cost data based on reported emissions and judgment as to the type of control to be used

- A development of capital, annualized cost and energy requirements for the facilities that will be affected, based on the generalized cost data but escalated for inflation and retrofit and other factors
- Aggregation of the findings for the plants affected in Massachusetts.

The generalized cost information used is presented in Control of Volatile Organic Emissions from Existing Stationary Sources, Volume I (EPA 450/2-76-028).

Additional cost data were supplied by equipment and material suppliers and published literature. Major coaters in Massachusetts, as well as in other states, were consulted to determine industry views on acceptable control methods and, in some cases, to confirm the cost estimating procedures. An example illustrating the cost calculation procedure used is presented in the appendix to this report.

3.1.5 Economic Impacts

The economic impacts were determined by: analyzing the lead time requirements to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability; comparing the direct costs of RACT control to various economic indicators; and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in the state.

The projected effect of RACT implementation on the product cost is based on an indicator which is the incremental cost per unit of production compared to the total sales or cost of the product within the state. This effect is estimated as follows:

- Relate incremental costs to total statewide figures.
- Also relate incremental costs to the part of the statewide production that is affected by the regulation (firms not now meeting RACT).
- Where data are available, show the range of ratios for individual plants.
- Where the industry has been segmented, show the range of cost ratios for applicable industry segments.

The incremental cost per unit of production is used as an indicator of potential price effect rather than a prediction of the price effect to be expected.

3.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of fabrics in the state. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of A" indicates hard data (data that are available for the base year); B" indicates data that are reasonably reliable, such as that extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 3-2, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 3-2
U.S. Environmental Protection Agency
DATA QUALITY--SURFACE COATING OF PAPER

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Date
Industry statistics		X	
Emissions[a]	X		
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

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[a] Emission data obtained from Massachusetts state emission inventory.

Source: Booz, Allen & Hamilton Inc.

3.2 INDUSTRY STATISTICS

Industry characteristics, statistics, and trends for fabric coating are presented in this section. This information forms the basis for assessing the total impact of implementing RACT for control of VOC emissions in this category upon the state economy and upon the individual firms concerned.

3.2.1 Size of the Industry

The Bureau of Census, in 1976 County Business Patterns, reported a total of about 613 plants in SIC categories in which plants coating fabrics in Massachusetts would be expected to be tabulated. Pertinent data concerning these plants are summarized in Exhibit 3-3, on the following page. As mentioned earlier, 24 plants were identified in which fabric coating, as defined in the proposed "fabric coating" regulation, is being used. All of these would be affected by the proposed regulations requiring VOC emissions control for facilities with potential emissions over 100 tons per year. However, since two of the facilities have existing controls equivalent to the RACT requirements, only 22 facilities will be directly affected by the proposed regulation. The 24 facilities are listed in Exhibit 3-4, following Exhibit 3-3.

As shown, these 24 affected firms are estimated to employ a total of about 4,527 people. The total annual value of shipments of the 24 firms is estimated at $221 million, by using the value of shipments per employee[1] characteristic of the SIC group by which each plant is identified. The 22 directly affected firms employ about 4,447 employees and have estimated annual shipments of about $216 million, using the same method of estimation.

3.2.2 Comparison of the Industry to the State Economy

A comparison of the value of shipments of these plants with the state economy indicates that these plants represent a small percentage of the total value of shipments by manufacturing plants and employ from 0.70 percent of the manufacturing workers in Massachusetts in the 22 directly affected plants to 0.78 percent in the 24 plants.

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[1] Based on 1976 Annual Survey of Manufactures data for Massachusetts

EXHIBIT 3-3

U.S. Environmental Protection Agency

INDUSTRY STATISTICS FOR PLANTS IN SIC CATEGORIES WHERE FABRIC COATING MAY BE USED IN MASSACHUSETTS

SIC	Name	Number of Firms	Number of Employees	Annual Payroll ($thousand)
2211	Broad woven fabrics mills, cotton	2	20-99	221-1,095[a]
2221	Broad woven fabric mills, man-made and silk	17	3,653	34,830
2241	Narrow fabrics and other, small wares mills	25	1,250	10,651
2258	Warp knit fabric mills	4	137	1,307
2261	Finishers of broad woven fabrics of cotton	11	1,000-2,499	11,061-27,643[a]
2262	Finishers of broad woven fabrics of man-made fiber and silk	16	3,251	34,369
2269	Finishers of textiles, n.e.c.	8	188	1,803
2295	Coated fabrics, not rubberized	20	2,342	28,958
2297	Nonwoven fabrics	7	1,826	22,476
3069	Fabricated rubber products, n.e.c.	54	5,439	69,101
3079	Miscellaneous plastics products	414	20,885	217,624
3291	Abrasive products	23	5,806	73,448
3293	Gaskets, packing, sealing devices	12	471	5,951
		613	46,268-47,846	511,806-529,292

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[a] Not reported to protect proprietary information; therefore, estimated based on $11,061 per employee, which is an average for the remaining firms.

Source: 1976 County Business Patterns, U.S. Department of Commerce.

EXHIBIT 3-4
U.S. Environmental Protection Agency
FIRMS EXPECTED TO BE AFFECTED BY THE FABRIC COATING RACT REGULATIONS IN MASSACHUSETTS

Firm	Location	Employees
Coaters Inc.	New Bedford	90
Flexcon Co.	Spencer	95
Pyrotex Corp	Leominster	50
Elfskin, Inc	Cherry Valley	125
Eli Sandman Co.[a]	Worcester	50
Industrial Polymer & Chemicals	Shrewsbury	70
Lewcott Chemicals & Plastics	Millbury	43
Plymouth Rubber Co.	Canton	900
Hub Fabric Leather Co.	Everett	20
Chase & Son Inc.	Randolph	100
Norton Co.	Walpole	40
Fay Specialties	Watertown	6
Hartz Mason	Watertown	104
Odell Co.	Watertown	50
Steadfast Rubber Co.	Easton	65
Malden Mills Inc.	Lawrence	1,500
Ideal Tape Co.	Lowell	80
Pandel Bradford, Inc.	Lowell (Rogers St. Plant)	340
Pandel Bradford, Inc.	Lowell (Market St. Plant)	300
Majalite Corp.	Lowell	40
Startex	Newburyport	200
Vernon Plastics	Haverhill	200
Nylco Products	Clinton	70
Vulpex, Inc.[a]	Abington	30
		4,527

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[a] . Plants with existing controls.

Source: Massachusetts Department of Environmental Quality Engineering and Booz, Allen and Hamilton Inc.

3.2.3 Historical and Future Patterns of the Industry

The fabric coating industry in the U.S., except for the general economic slump in 1975, has shown a gradual but steady growth in sales and shipments over the last several years, as demonstrated by Exhibits 3-5 and 3-6, on the following pages. The largest growth in terms of dollar value of shipments was for vinyl coated fabrics which increased by $215.5 million in shipments from 1972 to 1976, compared with an increase of $301 million for all coated fabrics. Pyroxylin (cellulose nitrate) coatings, because of their low cost and ease of application, still continue to occupy a steady though proportionately smaller share of the market. Natural and artificial rubber coated fabrics, because of unique properties not obtainable with plastic materials, also maintain a substantial (about 10 percent) share of the coated fabric market. Vinyl and urethane coatings, however, are replacing a larger share of both markets.

EXHIBIT 3-5

U.S. Environmental Protection Agency
U.S. ANNUAL VALUE OF SHIPMENTS OF COATED FABRICS
($ millions)

Item	1972	1973	1974	1975	1976
Pyroxylin-Coated Fabrics	876.5	693.7	728.7	681.5	817.4
Pyroxylin-Coated Fabrics	26.3	27.3	34.5	28.0	32.5
Vinyl Coated Fabrics	601.9	693.7	728.7	681.5	817.4
Other Coated Fabrics	154.1	188.0	212.6	202.7	213.8
Coated Fabrics, not rubberized	26.3	27.4	(13.6)[a]	(1.4)[a]	(33.8)[a]
Rubber Coated Fabrics	67.9	73.6[b]	83.5[b]	72.0[b]	80.0[b]
TOTAL	876.5	1,011.9	1,156.5	985.6	1,177.5

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a. Values obtained by difference from gross shipments of all coated fabrics, not rubberized.

b. Booz, Allen estimate based on shipments of "Other Rubber Goods, N.E.C.", SIC Code 30698

Source: 1976 Annual Survey of Manufactures

EXHIBIT 3-6
U.S. Environmental Protection Agency
U.S. ANNUAL SHIPMENTS OF BACKING MATERIALS FOR COATED FABRICS
(in millions of pounds)

	1972	1973	1974	1975	1976
Transportation Fabric, all fibers[a]	95.4	100.9	64.6	65.3	81.5
Coated and Protective Fabrics[b]	133.7	149.3	167.5	137.8	177.6
TOTAL	229.1	250.2	232.2	203.1	259.1

Notes:

a. Transportation fabric includes auto seat upholstery and slipcovers, sidewall, headlining and sheeting. The cotton poundage include the knit and woven fabric used as the backing for vinyl sheeting. The item includes convertible auto tops & replacements thereof, as well as upholstery used in other kinds of transportation, such as airplanes, railroad & subway cars, buses, etc. It does not include seat padding, transportation rugs, window channeling flocking, tassels, trim, etc., or the textile glass fiber used in reinforced plastic seating for subways, buses, etc.

b. Coated and protective fabrics includes parachutes, deceleration chutes and tow targets; awning; beach, garden & tractor umbrellas; inflatable dunnage and cushions, air-supported structures and automotive air-spring diaphragms; boat and pool covers; tarpaulin covers for athletic fields, etc.; also, the substrates used for vinyl sheeting. The cotton poundage include awnings, boat covers, tarpaulins and tents. Not included here are the cotton poundages used for vinyl substrates. Such poundages are tabulated with their appropriate end use, i.e., transportation upholstery, upholstery etc. Does not include man-made fiber surfaces for recreational fields.

Source: Textile Economics Bureau, Technicon, November 1977

3.3 TECHNICAL SITUATION IN THE INDUSTRY

This section describes the principal materials and processes used in fabric and vinyl coating and various methods which are considered to be reasonably available control technology to meet proposed regulations. The proposed RACT guidelines for fabric coating and an estimate of the total VOC emission reduction possible if the guidelines are implemented in the state are also presented.

3.3.1 General Coating Process Description

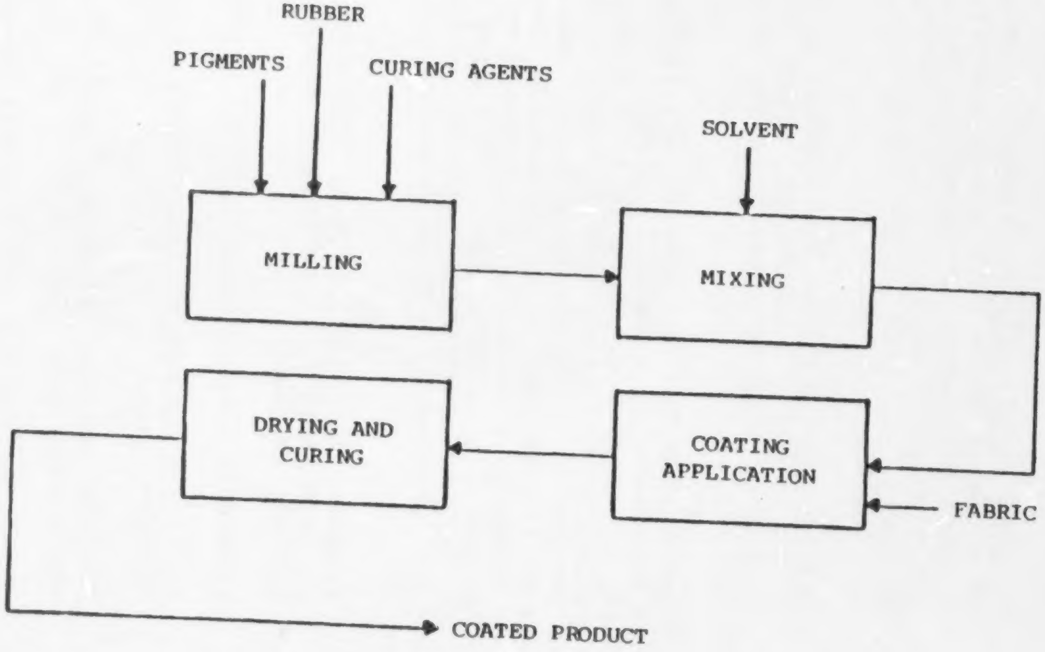
Fabrics are coated primarily to render them resistant to penetration by various fluids or gases, improve abrasion resistance or modify the appearance or texture. Typical examples are materials used in shower curtains; rubber life rafts; balloons; drapery material; synthetic leathers for shoes, upholstery or luggage; table cloths; and outdoor clothing. The base fabrics can be asbestos fiber cloth, burlap and pile, cotton drill, duck canvas, glass fabrics, knit cotton or rayon, nonwoven fabrics or nylon sheeting. In the case of coating of vinyls, the substrate is a flexible vinyl sheet or cloth-supported vinyl on which a coating is applied to enhance the appearance or durability of the vinyl surface.

Typical coating materials are rubber compounds, vinyl resins of various types, polyesters, polyurethanes, nitrocellulose resins, oleo resins, phenolic resins, epoxy resins and polyethylene. Various techniques are used for applying these coatings as melts, plastisols, latexes, solutions or other forms. Since these proposed guidelines are primarily concerned with coatings applied as solutions, where large volumes of volatile organic materials can be emitted, the following discussions will be limited primarily to processes for coating with coating materials dissolved in organic solvents.

Exhibit 3-7, on the following page, shows the general operations involved in most fabric or vinyl coating operations. Four basic operations are involved:

- Milling -- Milling is primarily restricted to coatings containing rubber. Natural and synthetic rubbers are usually milled with pigments, curing agents and fillers to produce a homogeneous mass that can be dissolved in a suitable solvent. Organic solvents are not usually involved in the milling process; thus, there are seldom any organic emissions from this operation.

Exhibit 3-7
U.S. Environmental Protection Agency
TYPICAL FABRIC COATING OPERATION


RUBBER
PIGMENTS
CURING AGENTS
SOLVENT
MILLING
MIXING
DRYING AND CURING
COATING APPLICATION
FABRIC
COATED PRODUCT

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-76-028)

DRAFT

- Mixing -- Mixing is the dissolution of solids from the milling process in a solvent. The formulation is usually mixed at ambient temperatures. Sometimes only small fugitive emissions occur. However, some vinyl coaters estimate that as much as 25 percent of plant solvents are lost in mixing operations.

- Coating Application -- Fabric is usually coated by either a knife or a roller coater. Both methods are basically spreading techniques used for high speed application of coatings to flat surfaces. In some unique situations, dip coating may be used.

- Drying and Curing -- The coating is dried or cured in a final operation, using heat or radiation to remove the solvents or set the coating.

In general, the coating line is the largest source of solvent emissions in a fabric coating plant, and the most readily controllable. Some coating plants report that more than 70 percent of solvents used within the plant are emitted from the coating line. Other plants, especially those involved in vinyl coating, report that only 40 to 60 percent of solvents purchased by the plant are emitted from the coating line. Remaining solvents are lost as fugitive emissions from other stages of processing and in cleanup. These fugitive losses are generated by:

- Transfer from rail cars or tank trucks to storage tanks, and subsequent transfer to processing tanks

- Breathing losses from vents on storage tanks

- Agitation of mixing tanks which are vented to the atmosphere

- Solvent evaporation from cleanup of the coating applicator when coating color or type is changed

- Handling, storage and disposal of solvent soaked cleaning rags

- Waste ink disposal -- Waste ink is usually distilled to recover much of the solvent. After distillation the sludge, which still contains some solvent, is usually dumped in a landfill

- Losses from drums used to store coatings which are being pumped onto a coating applicator. These are usually drums which are not hooded and may not even be covered
- Cleaning empty coating durms with solvent
- Cleaning coating lines with solvent
- Evaporation of solvent from the coated fabric after it leaves the coating line. From 2 percent to 3 percent of total plant solvent usage remains in the product. Half of this may eventually evaporate into the air.

Control techniques for the above types of sources include tightly fitting covers for open tanks, collection hoods for areas where solvent is used for cleanup and closed containers for solvent wiping cloths.

3.3.2 Nature of Coating Materials Used

Coating formulations used in organic solventborne coatings normally incorporate film-forming materials, plasticizers, pigments and solvents. A multitude of organic solvents are used; solvents such as acetone toluene, heptane, xylene, methyl ethylketone, isobutyl alcohol and tetrahydrofuran are widely used in rubber, vinyl and urethane coating formulations.

In some cases, a single solvent is used, but more generally mixed solvents are employed to obtain optimum drying rates and coating mixture properties. Too rapid drying results in undesirable surface properties such as "orange peel" or other effects; improper viscosity or solvency of the coating mixture may prevent proper coating of the substrate; slow drying can limit production rates.

As discussed earlier, a number of film-forming materials are used. Typical coating materials are epoxy resins, melamine-formaldehyde resins, nitrocellulose resins oleoresinous compounds, phenolic resins, polyesters, polyurethanes, rubber compounds and vinyl resins. Miscellaneous resins (such as polyethylene and ethylene copolymers, starch and casein compounds, and acrylic resins) are not discussed here since most use coating techniques which are not solvent related.

Plasticizers are added where the flexibility of the coating is important, such as in clothing or upholstery fabric. Pigments or opacifiers are added to clear film formers to provide the colors or other appearance effects desired or are used in inks as a separate coating operation to modify the surface of the coating. Pigments applied as a printed coating are normally further coated with a clear finish coat to provide the luster desired and provide protection from wear.

3.3.3 Coating Processes Commonly Used

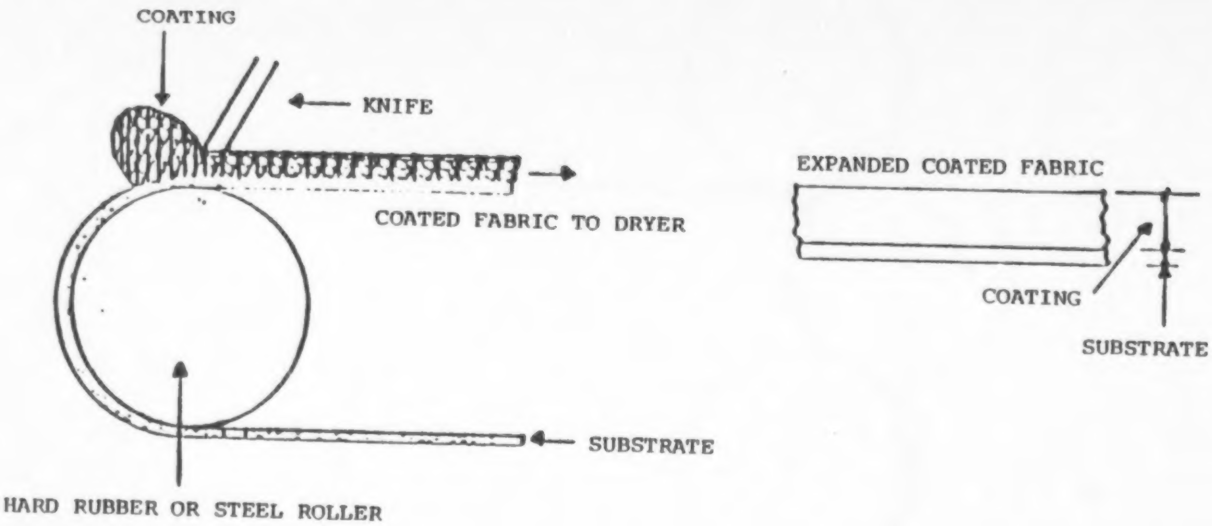
Exhibits 3-8 and 3-9, on the following pages, illustrate the two major methods of applying solvent-based coatings--knife coating and roll coating.

- Knife coating is probably the least expensive method. The substrate is held flat by a roller and drawn beneath a knife that spreads the viscous coating evenly over the full width of the fabric. Knife coating may not be appropriate for coating materials such as certain unstable knitgoods, or where a high degree of accuracy in the coating thickness is required.

- Roller coating is done by applying the coating material to the moving fabric, in a direction opposite to the movement of the substrate, by hard rubber or steel rolls. The depth of the coating is determined by the gap between rolls (A and B as shown in Exhibit 3-7). The coating that is transferred from A to B is then transferred to the substrate from roll B. Unlike knife coaters, roller coaters apply a coating of constant thickness without regard to fabric irregularities.

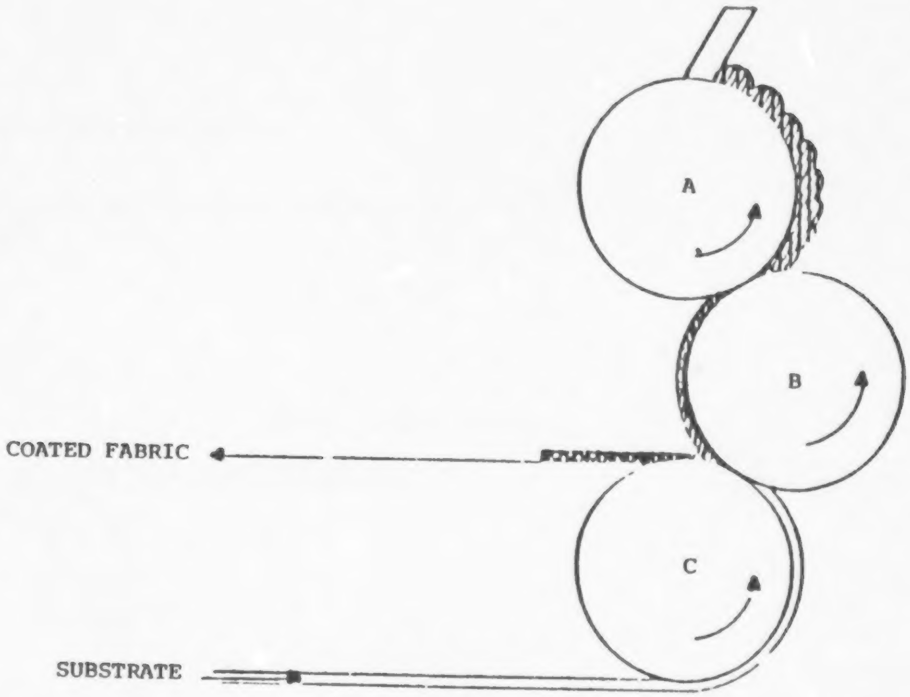
Rotogravure printing is widely used in vinyl coating of fabrics and is a large source of solvent emissions. Rotogravure printing uses a roll coating technique in which the pattern to be printed is etched as a series of thousands of tiny recessed dots on the coating roll. Ink from a reservoir is picked up in these recessed dots and is transferred to the fabric surface. Shadow prints are used to simulate leather grain. A variety of patterns are printed on such items as vinyl wall paper. A transparent protective topcoat over the printed pattern is also applied with rotogravure techniques.

Exhibit 3-8
U.S. Environmental Protection Agency
KNIFE COATING OF FABRIC


COATING
KNIFE
COATED FABRIC TO DRYER
SUBSTRATE
HARD RUBBER OR STEEL ROLLER
EXPANDED COATED FABRIC
COATING
SUBSTRATE

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-76-028).

Exhibit 3-9
U.S. Environmental Protection Agency
ROLLER COATING OF FABRIC


A
B
C
COATED FABRIC
SUBSTRATE

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-76-028).

Solvent emissions from the coating applicator account for 25 to 35 percent of all solvent emitted from a coating line. This solvent may be collected by totally enclosing the coating applicator in a small room or booth and sending all booth exhaust to a control device. However, a total enclosure of the coater may be difficult to retrofit on many existing lines. Another alternative is to cover the coater with a hood which can collect most of the solvent emissions.

The final operation in the coating process is the drying and curing of the applied coating material. Sixty-five to 75 percent of solvent emissions from the coating line usually occur in this step. In most ovens, almost all solvent emissions are captured and vented with exhaust gases. On some coating lines the emissions from the coating applicator hood are ducted to the oven and included with the oven exhaust.

Estimated and reported solvent concentration levels from drying operations range between 5 and 40 percent of the LEL (lower explosion limit). Typically, drying ovens are designed to process fabric on a continuous basis, operating with a web or conveyor feed system. Ovens can be enclosed or semienclosed and, depending on size, may exhaust from a few thousand to tens of thousands of cubic feet per minute of air. If an add-on control device is to be installed, it is generally in the owner's best interest to minimize the volume of air since the cost of add-on control devices is largely determined by the amount of air treated.

The oven heat increases the evaporation rate of the solvent and, with some coatings, will produce chemical changes within the coating solids to give desired properties to the product. In many cases, evaporation rates are controlled to give the desired properties to the coated fabric.

Many drying ovens in older plants are only semienclosed. As a consequence, they draw in excessive dilution air. Solvent concentrations range between 5 and 12 percent of the LEL according to both calculations and reports by industry. However, levels of up to 50 percent of the LEL are possible if proper safety devices are used. At least three plants in the United States are operated at 40 to 50 percent of LEL.

3.3.4 Emissions and Current Controls

The reported and potential VOC emissions from the 24 plants likely to be affected by RACT guidelines in the state are summarized in Exhibit 3-10, on the following page.

The total reported VOC emissions from fabric coating lines in the 22 directly affected plants were 10,860 tons in 1976. No controls are now used by these plants.

The two plants with current controls had an estimated total annual emission of 231 tons before control and 40 tons after control. One of the two plants uses water-based coating, which was assumed to have a control efficiency of 81 percent. The other plant uses a water scrubber to remove methanol, reportedly with 90 percent removal efficiency.

3.3.5 RACT Guidelines

The RACT guidelines for control of VOC emissions from fabric coating require that emissions from coating lines be limited to a level of 2.9 pounds per gallon of coating for coating of fabric substrates and 3.8 pounds per gallon for coating of vinyl substrates. Both limits are based upon the use of an add-on device which recovers or destroys 81 percent of the VOC introduced in the coating. This the U.S. EPA considers to be achievable by capture of 90 percent of the VOC emissions and destruction of these emissions in an add-on device, such as an incinerator. In some cases, use of alternative low solvent or solventless coatings can also be used to meet these limits.

EXHIBIT 3-10
U.S. Environmental Protection Agency
VOC EMISSIONS FROM FABRIC COATING PLANTS IN MASSACHUSETTS

Firm[a]	1976 VOC Emissions[b] (Tons/Yr)
Coaters Inc.	1,686
Flexcon Co.	988
Pyrotex Corp.	103
Elfskin, Inc.	115
Eli Sandman Co.	5[c]
Industrial Polymer & Chemicals	130
Lewcott Chemicals & Plastics	102
Plymouth Rubber Co.	2,401
Hub Fabric Leather Co.	72
Chase & Son Inc.	219
Norton Co.	281
Fay Specialties	34
Hartz Mason	309
Odell Co.	250
Steadfast Rubber Co.	1,092
Malden Mills Inc.	233
Ideal Tape Co.	800
Pandel Bradford, Inc. (Rogers St. plant)	584
Pandel Bradford, Inc. (Market St. plant)	1,148
Majalite Corp.	35
Startex	39
Vernon Plastics	82
Nylco Products	157
Vulpex, Inc.	35[d]
	10,900

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a. Location of the firms is listed in Exhibit 3-4.

b. After current controls; only two plants have current controls, as noted below.

c. This plant is reported to use a water scrubber to remove methanol with 90 percent removal efficiency.

d. This plant uses water-based coatings.

Source: Massachusetts Department of Environmental Quality Engineering.

3.4 ALTERNATIVE CONTROL METHODS

In this section are briefly discussed methods of low solvent and solventless systems, which have been demonstrated to be applicable to some fabric coating products, and the two principal add-on systems, incineration and carbon adsorption, generally used for emission control. This information has been extracted principally from the previously cited EPA report, Control of Volatile Organic Emissions from Existing Stationary Sources, Volumes I and II, which should be consulted for a more thorough discussion. In some instances, additional comment was obtained from coaters, coating material suppliers and control equipment manufacturers.

3.4.1 Low Solvent and Solventless Coatings

Organic emissions can be reduced 80 to 100 percent through use of coatings which inherently have low levels of organic solvents. Both high-solids and waterborne coatings are used. The actual reduction achievable depends on the organic solvent contents of the original coating and the new one. Using a coating which has a low organic solvent content may preclude the need for an emission control device. Often the coating equipment and procedures need not be changed when a plant converts to coatings low in organic solvent.

Although a number of companies have converted to low solvent coating, either in part or in total, one may not presume that low solvent coatings are universally applicable. Each coating line is somewhat unique and many coated fabrics have different specifications.

None of the plants identified were aware of suitable alternative coatings currently available which would meet the quality and performance standards required in all of their products. Some firms have, over the last several years, converted to waterborne coatings on some products and believe that, if sufficient time were allowed for research and development, a majority of their coatings could be replaced by low solvent ones. There may be some coatings which could not be replaced.

3.4.2 Incineration

Catalytic and direct thermal incineration processes convert hydrocarbons to carbon dioxide and water at high temperatures. Incineration is widely accepted as a reliable means of reducing hydrocarbon emissions by 90 percent or more.

Generally, the major disadvantage of this approach is the increased energy required to raise the exhaust gas temperatures over 1,200°F for direct incineration and 700°F for catalytic incineration. Natural gas is the most commonly used fuel, though propane, fuel oils or other fluid hydrocarbons can be employed. Fuel oil is not generally acceptable because of the sulfur oxides generated in combustion or the presence of catalyst poisons in the oil. Another problem is the generation of nitrogen oxides in direct fired incinerators resulting from the exposure of air to high-temperature flames.

The increased energy consumption can, in some cases, be reduced or eliminated by heat exchange of the exhaust gases with fresh emissions (primary heat recovery) or by use of the hot exhaust gases in process applications (secondary heat recovery). Typical use of secondary heat recovery is for oven heat in drying or curing ovens. In fact, with efficient primary exchange and secondary heat recovery, total fuel consumption of an incinerator-oven system can be less than that for the oven before the incinerator is added. The heat required to sustain the system comes from combustion of volatile organic compounds in the exhausts.

Both catalytic and direct fired systems are capable of high heat recovery efficiency if several conditions occur:

- VOC concentrations are or can be increased to 8 percent to 10 percent or more of their lower explosion limit (LEL).
- Oven temperatures are sufficently high to enable use of the sensible heat in the exhaust gases after primary heat exchange. Usually, oven temperatures above 140°F are sufficient to allow 85 percent or more overall heat recovery.
- Where catalytic incinerators are used, no compounds must be present in the gases treated which could poison or blind the catalyst.

In most coating operations, drying and curing temperatures are 250°F or higher. By reduction of air flow to reach exhaust levels of 8 to 10 percent or higher and proper design of the heat recovery system, it may be possible to achieve overall heat recoveries of 85 percent or greater.

3.4.3 Carbon Adsorption

Carbon adsorption has been used since the 1930s for collecting solvents emitted from coating operations. Most operational systems on coating lines were installed because they were profitable. Pollution control has usually been a minor concern. Carbon adsorption systems on coating lines range in size from a few thousand to tens of thousands of cubic feet per minute. Exhausts from several coating lines are often manifolded together to permit one carbon adsorption unit to serve several coating lines.

The greatest obstacle to the economical use of carbon adsorption is that, in some cases, reusing solvent may be difficult. In many coating formulations, a mixture of several solvents is needed to attain the desired solvency and evaporation rates. If this solvent mixture is recovered, it sometimes cannot be reused in formulating new batches of coatings. Also if different coating lines within the plant use different solvents and are all ducted to one carbon adsorption system, then there may be difficulty reusing the collected solvent mixture. In this case, solvents must be separated by distillation.

However, in some cases azeotropic, constant boiling, mixtures can occur which can be separated only by specialized techniques. Most coating firms would not have the skills necessary for the complex distillation and separation procedures needed. For small adsorption systems, the additional separation expenses would probably exceed the cost of fresh solvent.

Also, adsorption of solvents containing water soluble compounds (such as alcohols, ketones or esters) can present a secondary pollution problem where steam is used for bed regeneration. Additional treatment of the condensed steam with its content of dissolved organics would be required, increasing the complexity of the solvent recovery system and its cost.

3.5 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

This section discusses the projected costs of control for fabric coating in the state based on the emissions as discussed in Section 3.3.4 of this report. Where possible, the validity of the costs were confirmed with coating firms and equipment manufacturers.

Most coaters interviewed in Massachusetts who had examined alternative control systems indicated carbon adsorption as their preferred control option because the solvent may be recovered. Some coaters may have to reformulate their current solvents to be able to recover the solvents. Several coaters preferred incineration because of low initial cost. Some coaters in Massachusetts and other states are investigating switching to water-based coatings or low solvent coatings. However, their experience to date indicates that suitable substitute coatings with special properties (such as durability under washing and dry cleaning application and fire resistance) are not yet available. The development of such coating will require a long lead time for research and testing. Since sufficient cost data for water-based or low solvent coatings are not available, it is assumed (for cost estimating purposes) that fabric coaters in Massachusetts will use incineration or carbon adsorption systems to meet the RACT guidelines.

3.5.1 Cost of Alternative Control Systems

Estimated costs of compliance were based on the assumption that exhaust flow rates can be reduced sufficiently to obtain LEL levels of 25 percent. This is possible with well-designed capture systems where intake air flows can be reduced or where product characteristics allow. Lower LEL levels require higher air flow and thus result in higher control costs.

Incinerator or adsorber costs are a function of equipment size, which varies generally with air flow rate. In most plants, it is impractical to manifold exhausts so that all exhausts could be treated in one add-on emission control system. Also, it would be difficult to use secondary heat recovery on ovens where the incinerator is remote from the oven.

3.5.2 Estimated Statewide Costs

The total emissions considered to be applicable under RACT, as discussed in Section 3.3.4 of this report, are about 10,860 tons per year for the 22 directly affected firms. Nine firms indicated a preference for carbon adsorption systems and five for incineration to comply with the RACT requirements. The others either had not investigated the control option or were unwilling to discuss their plans. For the firms in this last group, control options were distributed in the same proportion as in the first group.

Total costs of compliance were, therefore, based on 9,191 tons per year of emissions being treated by carbon adsorption systems. The remainder, 1,669 tons per year, was assumed to be treated by incineration.

For incineration and adsorption costs, the capital and annualized costs presented in Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. I (EPA-450/2-76-028) were used. This report projects estimated costs for the control system as a function of total air flow rate.

The air flow rates for the affected firms were determined on the assumption of a 25 percent approach to LEL, other assumptions summarized in Exhibit 3-11, on the following page, and the firm's current estimated emissions. These air flow rates were then used to estimate costs from EPA-450/2-76-028.

By applying the generalized costs in EPA-450/2-76-028 and correcting for inflation and differences in operating hours, combined capital costs for carbon adsorption and incineration were estimated to be $12.8 million, with annualized costs varying from $2.5 million with solvent recovery at market values to $3.4 million without solvent recovery. An example of the calculation procedure used for an individual plant is presented in the appendix to this report. In adjusting for inflationary increases from mid-1975 (base period for EPA-450/2-76-028 data) to mid-1977, an average inflation rate of 8 percent per year[1] was used.

However, discussions with equipment manufacturers and coaters and review of published information indicated that these capital costs are probably three to four times lower than those experienced in recent retrofit situations. This issue is also addressed in EPA-450/2-76-028

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[1] Based on Chemical Engineering magazine process cost indices for this period.

EXHIBIT 3-11
U.S. Environmental Protection Agency
SUMMARY OF ASSUMPTIONS USED IN COST ESTIMATES

Assumptions

15 percent of emissions are controlled by incineration with primary heat recovery; 85 percent by carbon adsorption[a] assuming solvent is recovered at market value or with no credit as noted.

25 percent LEL is equal to 3,000 ppm of toluene by volume

Air flow can be reduced to reach 25 percent LEL.

Annual operating hours for the affected firms vary from 2,000 to 8,760.

Other assumptions are as estimated in Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. I: Control Methods for Surface-Coating Operations, EPA-450/2-76-028, and are valid.

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[a] This split was determined from information supplied by firms involved in interviews.

Source: Booz, Allen & Hamilton Inc.

which indicated that baseline capital costs could be 1.5 to 3 times higher because of various retrofit difficulties.

Therefore, using multipliers of three and four, it is estimated that actual capital costs for all affected fabric coaters in the state are more likely to range from $38 million to $51 million, with corresponding annualized costs of $10 million to $13.1 million with no solvent recovery and $9.8 million to $12.7 million with solvent recovery at market value. Annualized capital charges (at 25 percent of capital per year) are $9.5 million to $12.8 million of these annualized costs.

The capital costs to individual firms are estimated to vary from about $280,000 to $7.5 million and the corresponding annualized costs from $61,000 to $1.8 million.

3.5.3 Estimated Emission Reduction

Assuming that 90 percent of all solvents used in coating operations can be collected by properly designed hoods and ovens, emissions could be reduced by about 8,800 tons per year from the 22 directly affected firms. This is based on a 90 percent reduction of emissions in an incinerator or a carbon adsorber (an overall reduction in emissions of 81 percent). This reduction represents 81 percent of those emissions affected by RACT (emissions from the 22 directly affected firms).

3.6 DIRECT ECONOMIC IMPACTS

This section presents the direct economic implications of the RACT guidelines for surface coating of fabrics on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost pass-through), state economic variables and capital investment.

3.6.1 RACT Timing

Current proposed guidelines for fabric coating suggest several compliance deadlines for alternative methods of compliance.[1] Generally, for add-on systems, they call for installation of equipment and demonstration by mid-1980 or late 1980; for low solvent systems, by late 1980 or mid-1981, depending upon the degree of research and development needed. Major coaters, material suppliers and equipment manufacturers generally believe these deadlines to be unattainable for the fabric coating industry.

- Normally, large incinerator and carbon adsorption systems will require about a year or more from receipt of purchase order to install and start up the system. Engineering may require three months or more, fabrication three to six months and installation and startup as long as three months. A major fabric coater, with considerable experience with similar installations, estimates that the complete cycle of installation from initial selection of control method to testing of the system would require 37 months, plus an initial 13 months to establish an economically sound method of control.
- Only a small number of companies manufacture incineration systems with proven high heat recovery. The cumulative effect of equipment requirements of all firms in the U.S. needing control devices could severely impede the ability of these firms to supply equipment. In

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[1] Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001.

some cases, the most efficient devices are only now undergoing initial trials, and no production capacity has been developed.

- A major coating firm estimates that the use of low solvent or solventless coatings may take as long as 68 months from initial research, through product evaluation and customer acceptance to final production. Product and process development alone may take as long as 24 months and product evaluation over 14 months.

In general, it appears that if either add-on control systems are used or new low solvent systems need to be developed, deadlines may need to be extended. Because there may be significant advantages in low solvent systems but such systems are not now available, a period, such as five years, could be allowed for development since this would be considered to be innovative technology.

3.6.2 Technical Feasibility Issues

As discussed above, low solvent or solventless materials are used in many coating operations. At present, however, many types of solvent-based systems have no satisfactory replacement. The alternative materials generally do not meet the product quality standards demanded by the coaters. Additional development is needed and will require the combined efforts of both the coaters (who must maintain product quality) and the coating material suppliers. Ideally, the new coating materials should be adaptable to existing coating equipment to minimize additional capital investment.

As discussed above, both incineration and carbon adsorption are not completely satisfactory add-on control systems. Incineration requires large volumes of additional fuel if good heat recovery is not achieved; carbon adsorption is not usable on some coating systems because of the multiplicity of compounds used in solvent mixtures.

3.6.3 Comparison of Costs with Selected Economic Indicators

The net increase in annualized costs to the affected 22 coaters was estimated at $9.1 million to $13.1 million. These additional costs are projected to represent 4.2 percent to 6.1 percent of the total annual value of shipments of the 22 firms directly affected by the proposed regulations in Massachusetts. This ratio would be approximately the same if the value of shipments of the two firms that have current controls is included. These annualized costs in terms of the total value of manufacturing shipments in the state ($27.9 billion) represent about 0.03 to about 0.05 percent. For individual firms annualized compliance costs as a fraction of the total value of shipment could range from 0.4 to 30 percent; in the first instance fabric coating is only a part of the plant's operations while in the latter it is the principal activity. Assuming a "direct pass-through" of the costs for affected coaters, prices could be expected to increase by about the same fraction.

The preceding estimates of costs as a fraction of the total value of shipments can be used an approximate measure of price increases. However, in some cases only a part of the business of a firm may be represented by fabric coating operations affected by the regulations and the actual price increase for the affected products may be higher. Such price increases may make these firms less competitive with firms not affected by similar regulations elsewhere.

The capital investments required to install the control equipment may be several times larger than the normal annual capital expenditure of the Massachusetts fabric coaters. Since many of these plants may be privately owned, raising the necessary capital for the control systems may be difficult. Several fabric coaters interviewed in the state indicated that indeed this might be the case.

3.6.4 Selected Secondary Economic Impacts

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

Total employment of the 22 directly affected fabric coaters represents about 0.8 percent of the total Massachusetts manufacturing workforce. None of the major plants interviewed indicated that they would close down. Closure of smaller firms would have a marginal effect on the state employment.

It is likely that market structure could be affected if small firms with limited capital access were to shut down. However, there was no indication of closure of smaller firms during Booz, Allen interviews with the industry representatives. Compliance capital costs appear to be several times larger than the normal capital expenditures for improvement or expansion for these firms. Total annualized costs of compliance, also, may have a significant impact on market structure since incremental costs are as high as 6 percent of the value of shipments for affected firms on an average basis to over 30 percent in an individual case. The effect of annualized costs on smaller firms is more pronounced because of the economies of scale characteristic of incinerators and carbon adsorbers.

Productivity is not expected to be affected except for a short period when lines must be shut down for modifications or installation of equipment.

3.6.5 Impact of Compliance Upon Energy Consumption

Based on the assumption that 15 percent of affected emissions would controlled by installation of direct fired incinerators with primary heat recovery only (at 35 percent efficiency) and the remainder by carbon adsorption, energy consumption is expected to increase by an amount equal to about 25,000 barrels of oil annually. The estimate is based on the assumptions that oven exhausts are about 300°F, that about 8 pounds of steam are used per pound of solvent recovered and that a barrel of oil is equivalent to 6.0 x 106 BTUs.

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Exhibit 3-12, on the following page, summarizes the conclusions and projected implications of the results from this study.

EXHIBIT 3-12(1)

U.S. Environmental Protection Agency
SUMMARY OF FINDINGS IN THE STUDY OF THE DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR FABRIC COATERS IN THE STATE OF MASSACHUSETTS

Current Situation	Discussion
Number of potentially affected facilities	22 plants in the state are expected to be directly affected by the emission limitations. Additionally there are two other firms currently with controls.
Indications of relative importance of industrial section to state economy	The 1977 value of shipments of these 22 plants is estimated to be about $216 million. They are estimated to employ 4,400 people.
Current industry technology trends	Newer plants are built with integrated coating and emission control systems; older plants are generally marginally competitive now.
1977 VOC emissions (actual)	Current emissions are estimated at about 10,860 tons/year from the affected plants.
Industry preferred method of VOC control to meet RACT guidelines	Carbon adsorption and direct fired incineration for short range, low solvent coatings are a long range goal.
Assumed method of VOC control to meet RACT guidelines	Carbon adsorption and direct fired incineration with primary heat recovery.

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Estimated to be $38 million to $51 million depending on retrofit situations. This is likely to be more than 100 percent of normal expenditures for the affected fabric coaters.
Annualized cost (statewide)	$9.8 million to $13.1 million annually depending upon the retrofit situations and whether the solvent can be recovered at market value or not. This represents 4 to 6 percent of the 1977 total value of shipments of the affected fabric coating operations. For individual firms, the cost ranges from 0.4 to 30 percent of one of the value of shipments.

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Affected Areas in Meeting RACT	Discussion
Price	Assuming a "direct cost pass-through" based on estimated total industry sales an average of 4 to 6 percent increase in price.
Energy	Annual energy requirements are expected to increase by approximately 25,000 equivlanet barrels of oil.
Productivity	No major impact.
Employment	At least one firm employing 90 people, will be severely impacted, and might be forced to close.
Market structure	Though no major impact is expected there are firms whose principal activity is coating and may be severely affected by the regulations.
RACT timing requirements (1982)	RACT guideline needs clear definition with respect to what processes are included, for enforcement. Equipment deliverables and installation of incineration systems prior to 1982 are expected to present problems. Development of low solvent systems is likely to extend beyond 1982.
Analysis difficulties	Retrofit situations and installations costs are highly variable. Type and cost of control depend on particular solvent systems used and reduction in air flow.
VOC emissions after control	Approximately 2,063 tons/year (19 percent of 1977 VOC emission level from affected plants).
Cost effectiveness of control	Annualized cost/annual ton of VOC reduction is in the range of $1,100 to $1,490 based on the total annualized costs and value of shipments of affected firms. For individual plants the costs range from $650 to $2,200 per annual ton of VOC reduction.

Source: Booz, Allen & Hamilton Inc.

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APPENDIX A

APPENDIX A
U.S. Environmental Protection Agency, Region I
EXAMPLE OF CAPITAL AND ANNUAL COST ESTIMATE

Cost estimates are based upon costs tabulated in Control of Volatile Organic Emissions from Existing Stationary Sources--Volume I: Control Methods for Surface-Coating Operations, EPA-450/2-76-028. They are, however, corrected for inflation, difficulty of retrofit and operating hours.

To correct for inflationary factors, both operating and capital costs were escalated by 8 percent per year.[a] The costs in the EPA report, according to EPA sources, are referenced to mid-1975. Hence, the escalation factor used to correct costs to mid-1977 was 1.17, 8 percent per year for two years.

To correct for a range of varying retrofit factors, capital costs were additionally adjusted by multiplying escalated capital costs by three and four. These retrofit factors (based on extensive interviews with incinerator manufacturers and users) can include not only situations in which increased costs may result from installation difficulties, but also situations in which new emission collection systems are needed or in which ovens and control systems may need modification to increase exhaust gas solvent concentrations, i.e., to approach more closely to the lower explosion limit (LEL).

The correction for hours of operation was made by multiplying operating costs by the ratio of actual operating hours to 5,840 hours per year. The period of 5,840 hours per year was used in the EPA report.

The following example, used for illustrative purposes only, should clarify the calculation procedure used for estimation of costs for control by incineration. Calculation of adsorber costs are similar. It is based upon the following set of operating conditions:

- Emissions--3,000 tons/year
- Operating hours--2,000
- Coating lines--10
- Solvent--toluene (LEL = 1.2 percent).

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[a] Based on process equipment cost indices, for June 1975, June 1976 and June 1977 in Chemical Engineering magazine.

The costs are calculated as follows:

1. Total air flow rate can be calculated using the following equation, based on ideal gas laws:

$$V = \frac{3.83 \times 10^6 \times E}{P \times (LEL) \times (MWS)}$$

Where:

V = Air flow in cubic feet per minute at 70°F and 1 atmosphere pressure

E = Emission rate in pounds of solvent per minute

P = Percent approach to LEL selected (25 percent in this example)

(LEL) = Lower explosion limit, in volume percent

(MWS) = Molecular weight of solvent (for toluene, 92).

For the example set of conditions:

$$E = \frac{3{,}000 \text{ tons} \times 2{,}000 \text{ lbs./tons}}{2{,}000 \text{ hrs.} \times 60 \text{ mins./hr.}} = 50 \text{ lbs./min.}$$

and

$$V = \frac{3.83 \times 10^6 \times 50 \text{ lbs./min.}}{25 \times (1.2) \times 92} = 69{,}400 \text{ SCFM}$$

2. In most cases, it is impractical to combine exhausts from several ovens so that a single incinerator could be used. Therefore, one incinerator is assumed to be used per coating line. Thus, air flow rate per incinerator is:

$$\frac{69{,}400}{10} = 6{,}900 \text{ SCFM}$$

3. Figure 4-6 of EPA 450/2-76-028 is then used to obtain the capital cost of the average incinerator. For a 6,900 SCFM direct-fired incinerator, operating at 25 percent of LEL with primary heat recovery only, the 1975 capital costs is $130,000. Multiplying by 1.17 corrects for inflationary escalation from 1975 to 1977:

   $130,000 x 1.17 = $152,000

   Corrected for 3 to 4 times retrofit:

   $152,000 x 3 = $456,000 or x 4 = $608,000

4. For the total plant, using ten incinerators, the total costs would be $4,560,000 to $6,080,000.

5. Uncorrected annualized cost for the incinerator is found from Figure 4-8 of EPA 450/2-76-028; to be $35,000.

   Uncorrected annual operating cost is obtained by subtracting 25 percent of the uncorrected capital cost:

   $35,000 - 0.25 ($130,000) = $35,000 - $32,500 = $2,500

   Corrected annualized cost is obtained by multiplying by 1.17 to account for inflationary escalation and by (2,000/5,840) to correct for the difference between the actual number of operating hours and the 5,840 operating hours used in the EPA report. To this corrected annualized cost are added 25 percent of the escalated capital costs to include capital charges for interest, depreciation and maintenance as shown below:

Annual operating costs, corrected for escalation and operating time = $ 2,500 x 1.17 x $\frac{2,000}{5,840}$

= $ 1,000

Add 25 percent of corrected capital (3x) (.25 x $456,000) = $114,000

Corrected (3x) annualized cost = $115,000

Similarly for (4x) annualized cost = $153,000

The $115,000 and $153,000 annualized totals represent the average annualized cost of each of ten incinerators. The costs for the entire plant would be ten times these values or $1,115,000 to $1,530,000.